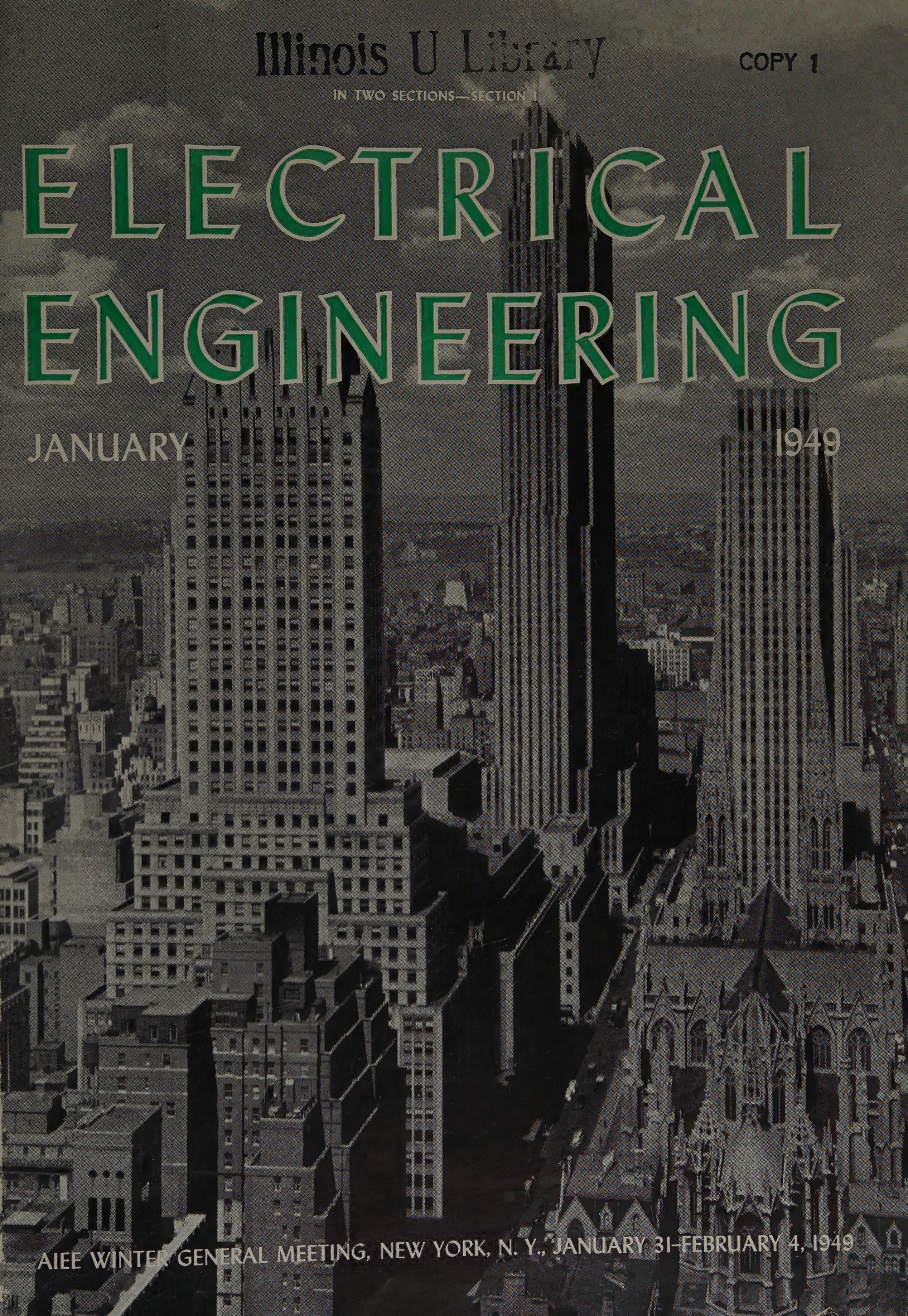
IN TWO SECTIONS—SECTION I

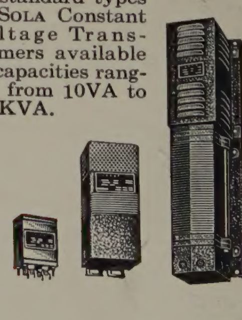
# ELECTRICAL ENGINEERING

JANUARY 1949



AIEE WINTER GENERAL MEETING, NEW YORK, N. Y., JANUARY 31–FEBRUARY 4, 1949





# Railroad Radio

W. D. HAILES
MEMBER AIEE

**A railroad radiotelephone service has been set up for use by railroad personnel to assist in railroad operations. Operating under rules of, and given a sizable number of frequencies by, the Federal Communications Commission, the railroads are using the new service in yards, terminals, harbors, and on main lines, as well as for emergencies. Equipment and housings have been designed to meet this new radio use.**

RAILROAD RADIO has come to mean a train communication system which provides 2-way telephone communication between mobile stations on railroad rolling stock, on the same or different trains, from land stations to these mobile stations, and between certain land stations of the system. It is used to assist railroad operation and to promote safety. The name "railroad radio" is used as a broad descriptive term to include two kinds of systems, one of which employs space radiation, while the other uses carrier currents induced in existing wayside wires to transmit messages. The latter system is called the inductive carrier system and requires the presence of open line wires along the railway to act as a grounded carrier circuit along which the signal can be transmitted between a remote land station and the mobile stations as they stand or move along the railroad near the line wires. The former system does not use, and does not require, the presence of wires. It is true space radio communication. Both systems are made to give the same sort of telephone communication, and they are used and controlled in an identical manner. It is necessary to operate a push-to-talk button with either system, as communication can take place in only one direction at a time.

In railroad radio a station on a locomotive or caboose is known as a mobile station, while a station on the wayside is called a land station. Communication between land and mobile stations is referred to as "point-to-train," between mobile stations on the same trains as "end-to-end," and between trains as "train-to-train" communication.

## HISTORICAL

The present activity and public interest in railroad radio began in 1944 with a special investigation and hearings by the Federal Communications Commission to determine how much in the way of increased safety and general benefit could be expected from the use of radiotelephone in various phases of railroad operation. The commission was convinced by its investigation that railroad radio would contribute to safety of life and property and should be of benefit to the public. It therefore issued an order, effective December 31, 1945, promulgating the rules and regulations governing a railroad radio service and allocating a number of frequencies for this service. The testimony at the FCC hearings showed that frequencies in the order of 150 to 200 megacycles would have suitable characteristics for railroad radio, and a block of frequencies between 158 and 162 megacycles was assigned to the railroad radio service. Other frequencies are also available for experimental work in connection with railroad operation. Some of these, in the ultrahigh-frequency (300 to 3,000 megacycle) band, may hold special advantages for certain needs of railroad radio.

The number of frequencies needed for railroad service was dictated by the problems encountered in and around large cities such as Chicago, Ill., where 33 different railroads operate within a relatively small area. It was necessary to assign frequencies enough to enable simultaneous communication without interference in these areas. Furthermore, it has been shown that it is not feasible for the railroad radio service to operate on a frequency-sharing schedule because the principal use of this service is to give instantaneous 2-way radiotelephone service to assist in train operation and promote safety. However, the same frequencies can be (and are) used in different areas without interference because at 160 megacycles the transmission distance is not much greater than the line of sight distance. This is one of the reasons for the selection of the frequencies mentioned for railroad radio service.

The Federal Communications Commission has liberalized the rules and regulations governing the use of railroad radio so as to facilitate its application to practical railroad operating conditions. Persons responsible for the adjustment and maintenance of the radio equipment (transmitters) must have at least a second-class radio operator's license, but this is not required of railroad employees in order for them to use the radio equipment. It is sufficient that they comply with the new FCC rule number 126. This provides for a biannual examination of employees by the railroad company on the rules that have been prepared by the Association of American Railroads for use by railroads in training their employees in the proper use of railroad radio.

## SALIENT CHARACTERISTICS

A typical station has a cabinet or case in which are housed the transmitting and receiving equipment. It has a speaker, a hand-set, or microphone, a control unit, and an antenna. For the inductive carrier type of system the antenna is supplanted by a coupling loop (at mobile stations) and a capacitor or other device (at land stations) to couple the station

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**W. D. Hailes** is electrical engineer for the General Railway Signal Company, Rochester, N. Y.


**Figure 1. Type-A inductive carrier transmitter, 70–200-kc frequency range (cover removed)**

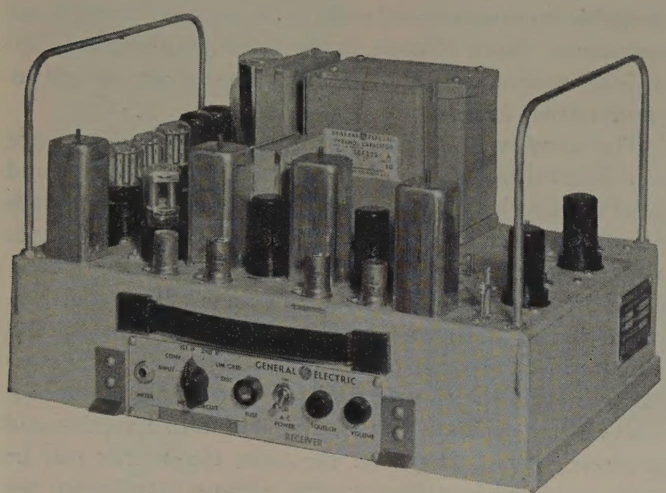



**Figure 2. Type-A inductive carrier receiver, 70–200-kc frequency range (cover removed)**

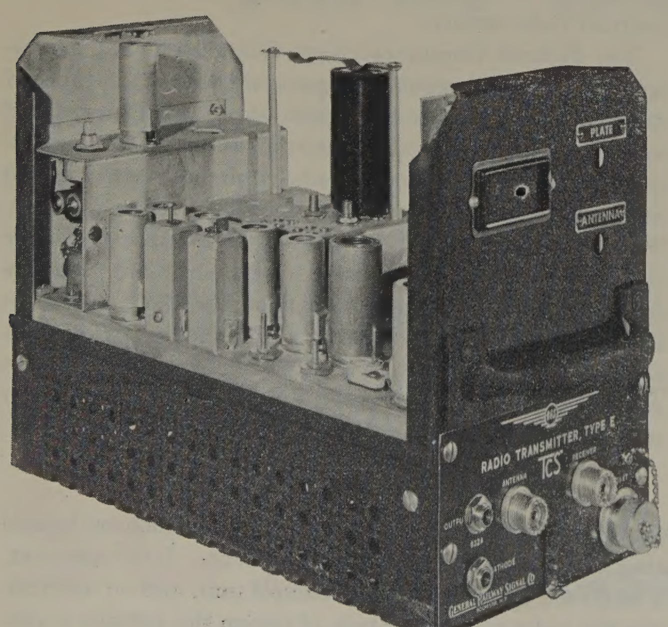



**Figure 3. Type-E very-high-frequency radio transmitter, 10-watt output, 158–162-megacycle frequency range (cover removed)**

with the line wires extending along the wayside. The loop on a mobile station is usually mounted so that its plane is vertical and parallel with the line wires along the wayside, so as to favor inductive coupling between the loop and line wires. Sufficient coupling can be obtained in this way to operate the system, provided the wires are not more than 150 to 200 feet away from the loop. The frequencies used at present for the inductive system range from 70 to 200 kc. The system is intended for operation at a power level that does not exceed the so-called "low power rule" of the FCC regulations; therefore, no station license is required at present for an inductive carrier station.

The range of operation for the inductive system varies with the nearness of the line wires to the mobile station, and other local conditions, so that it is not possible to give a definite figure for the useful range. However, under average conditions where an open-type line parallels the tracks, a land station usually can maintain solid communication with trains that are not more than 30 miles away. Under favorable conditions this distance might be as high as 40 to 50 miles. The range from train to train is usually considered to be 15 to 20 miles, if an open line parallels the tracks. The inductive carrier system will not operate without open line wires along the right of way to carry energy from station to station. However, the induced energy will follow open line wires up hill and down, through cuts and around obstructions that would interfere with space radio communication. This tends to give an advantage to the inductive carrier system for point-to-train communication over long sections of main line railroad, and in rugged country, because fewer land stations are required with the inductive carrier system. However, the wayside wires always must be within operable range of the mobile stations if communication is to be maintained between inductive carrier stations.

The range of operation of the 160-megacycle space radiation system is somewhat less than that of the inductive carrier system, but it is not dependent upon the proximity of open line wires. Space radiation at this frequency is diffracted around obstructions to a small degree, and reflected to a considerable extent, but the effective range is not much greater than the line of sight distance. Therefore, the range depends, for one thing, on the heights of the antennas. Land stations usually employ a high antenna, and often special arrays, to increase the operating range, but antennas on trains cannot be higher than about 16 feet above the rail, and sometimes must be foreshortened to fit into the small clearance between the top of a locomotive and the clearance diagram. Because of the reciprocal relationship[1] that exists between the transmitting and receiving properties of an antenna system, the additional height and gain of the land station antenna helps to overcome the handicap of low antennas on the mobile units. Therefore, the range for point-to-train is greater than that for train-to-train communication. A land station with an antenna 75 to 100 feet high ordinarily will give a point-to-train range of 12 to 18 miles, while the train-to-train range would be about four to eight miles. Adverse conditions, of course, can reduce these distances very sharply, while favorable conditions will increase them somewhat.

The operating ranges depend also on the amount of radio-frequency power used at the transmitter, and on the sensitivity of the receivers. The foregoing data apply to transmitters having 10- to 20-watt output and receivers with a sensitivity of one microvolt or less. The FCC regulations permit a maximum of 100 watts input to the final amplifier of a railroad radio transmitter. These higher-powered transmitters have an output of approximately 50 watts and give a little greater range. However, they are used mainly to increase the signal strength within the working area to over-ride the high noise levels that frequently exist in industrial areas.

The space radiation system can be used for all applications of railroad radio. It is particularly well suited for yard, terminal, and harbor service, where wide areas must be covered and where line wires are not present. The inductive carrier system is not well suited for yard and terminal area use because, as a rule, it would be necessary to put up line wire in many places. The need for line wires would, of course, prevent the use of the inductive carrier system for harbor service.

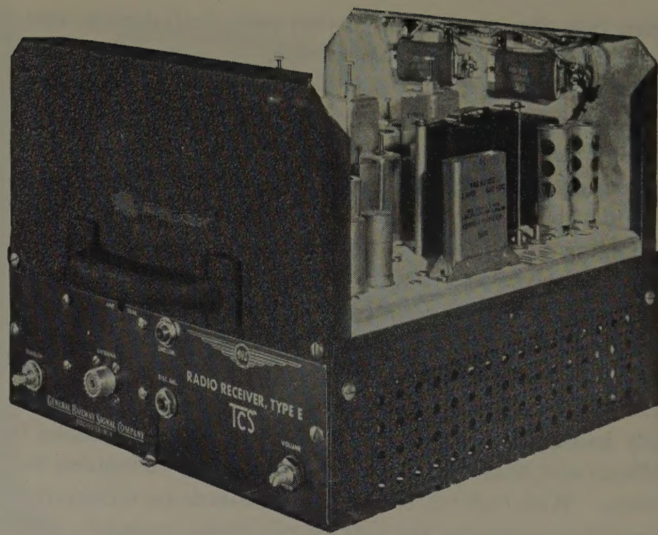



**Figure 4. Type-E very-high-frequency radio receiver, 158–162-megacycle frequency range (cover removed)**

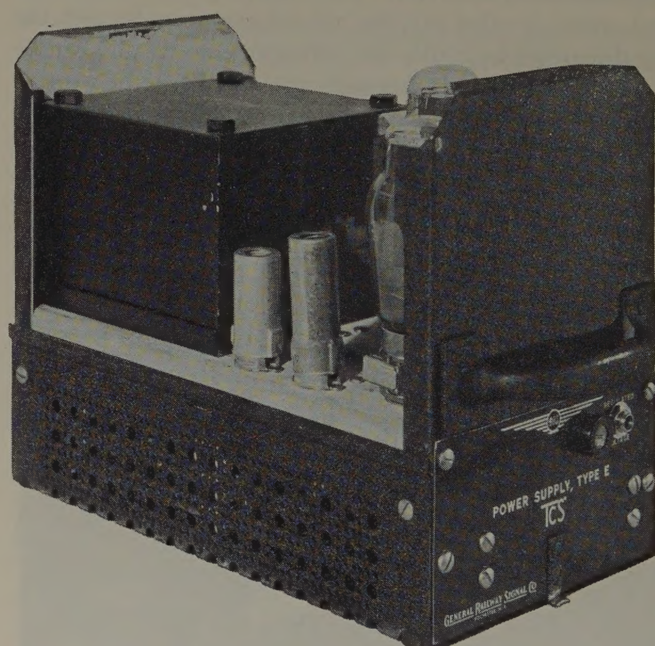



**Figure 5. Type-E power supply unit (cover removed); for heater, plate, and screen supplies of type-E transmitter and receiver**

## PRINCIPAL USES

There are three important divisions of railroad operation in which railroad radio now is being used. These are: operation of classification yards, particularly hump yards; operation of terminal areas, particularly where harbor tugs are employed; and the operation of main line service. Other uses of railroad radio are anticipated when more equipment becomes available and railroad personnel have become more familiar with radio and its possibilities.

Classification yards are railroad yards where freight trains are broken up and the individual cars classified as to destination and then regrouped to form new trains. Some are "flat" yards in which cars are pushed into the classification tracks, others have a hill or "hump" over which incoming trains are pushed, and the individual cars allowed to roll by gravity into the various classification tracks. In hump yard service, the wayside radio station is located at the crest of the hump. From this point the hump conductor directs the activities of the "pusher" and "trimmer" engines. The operation of pushing a train over the hump is started with radio instructions to the pusher engine to get behind the train on a certain track. At this point, the pusher engine is perhaps two miles from the hump, but by means of the 2-way radio the hump conductor and engineman on the pusher engine are able to co-operate as readily as if they were within speaking distance. Details are quickly arranged, and when all is ready the train is pushed up the hump. When the leading end arrives at the crest, the hump conductor begins separating the train into "cuts" of one or several cars, each cut bound for a particular classification track into which it rolls by gravity. It is during these humping and cutting operations that radio does a most effective job. It is not possible to give enough information by signals to enable the hump conductor and the pusher engineman to work to full advantage under all conditions. For example, when a coupler pin sticks, the radio saves much time by enabling the hump conductor to tell the pusher engineman just what is happening at the hump. If the radio is equipped with a self-checking system, it can be used safely to continue humping operations during periods of low visibility when it is not possible to see wayside signals.

In a terminal area railroad radio is used to provide 2-way telephone communication for the train- or yard-master with the locomotives working under his supervision. If a large number of locomotives are in use at one time, it may be advantageous to use a selective calling system so that only the locomotive with which communication is desired need hear the message.

For tugboat service, radio is used by the tug dispatcher in supervising and directing tugs as they move about a harbor performing a variety of duties. Changing weather and unexpected local conditions greatly affect operations in tugboat service. But with radio, the tug dispatcher talks directly with the tugboat captain and orders are revised promptly to meet new conditions. Communication be-

tween tugs also plays an important part, both during regular service, and in case of emergency.

Without radio many unnecessary trips are made by locomotives in terminal areas because the yard-master is unable to communicate with the locomotive crew to change his instructions to cover a new job that must be done in the same neighborhood where the locomotive is already operating. The same situation develops in the operation of railroad tugs. Here the loss of time is often much greater because of the longer distances and slower speeds involved. Crews of yard locomotives and of railroad tugs are instructed to report in over field telephones when they can get to these telephones. This, however, is far from satisfactory, particularly in tugboat service when weather conditions make it difficult and hazardous to put a man ashore to telephone for orders. With radio these delays and hazards are eliminated. Regular movements are carried out more promptly, and emergency conditions are handled with a minimum of delay and dislocation of service. For example, when a tug needs fuel, water, or other supplies, the tug captain talks with the tug dispatcher by radio, and arrangements usually can be made to combine this necessary operation with the work in hand to avoid loss of time and the need for a special trip.

Train operation on main lines probably offers the most spectacular parts for railroad radio to play. It is the application to this service that has caught the public interest and that can be the most exciting. It is not hard to imagine a variety of situations which will be reported by railroad radio in time to avoid serious damage or delay, examples of which already have occurred. In one instance, a station agent saw that several heavy timbers on a flat car had broken loose and were pounding the car ahead. He immediately reported it to the dispatcher and the train was notified by radio of this dangerous condition. The engineer was given full information about the situation, he made a normal stop, and no timbers were dislodged. The conductor saw that it would be necessary to set out the car and radioed this information to the dispatcher along with the car number and other details needed to expedite setting out the car and having the shifting load secured again. In this case, it is possible that the railroad radio may have prevented a serious accident, because the train was stopped before any of the timbers had shifted far enough to foul traffic on the adjacent track, or to fall off the car. In another instance a fire was discovered in a car about 20 cars ahead of the caboose of a freight train. The conductor instructed the engineer by radio to pull in at the next siding, cut his engine off, and back down to the main track to a point where he was able to put out the fire with the hose on the engine. Perhaps these were rather unusual opportunities for railroad radio, but there are many regular operations in main line service for which railroad radio is needed.

Trains in the same vicinity are able to talk to each other, and to one or more wayside stations. On freight trains,

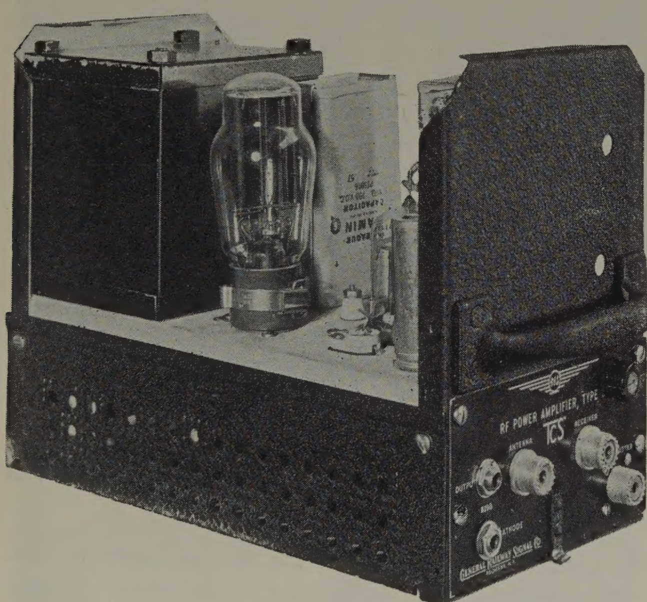



**Figure 6. Type-E very-high-frequency radio-frequency power amplifier, 158–162-megacycle frequency range (cover removed)**

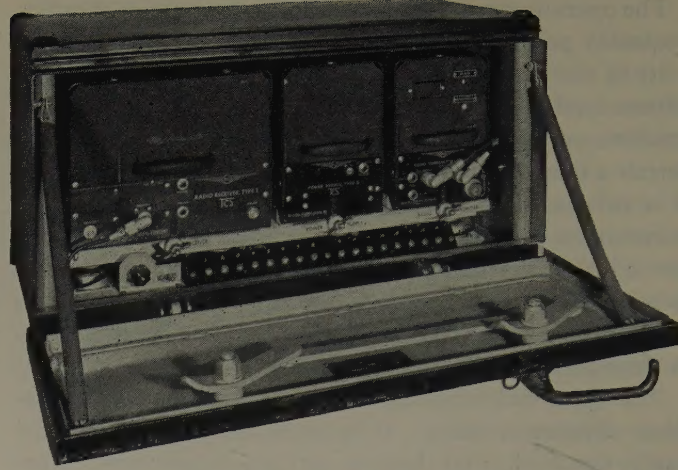
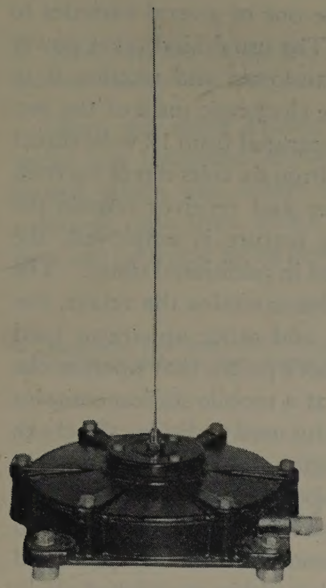
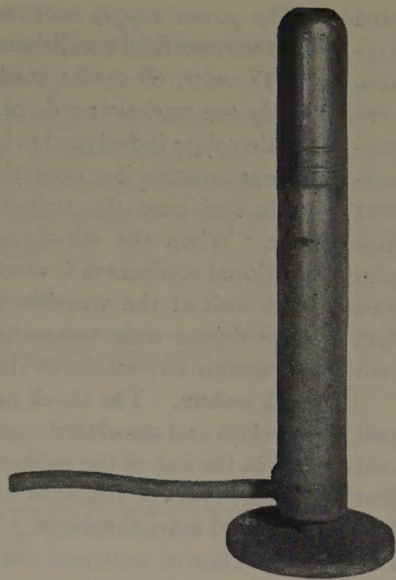


**Figure 7. Outdoor-type railroad radio equipment case (left to right: receiver, power supply, transmitter units on shock mounts)**


**Figure 8. Typical control unit, channel-switching railroad radio installation**





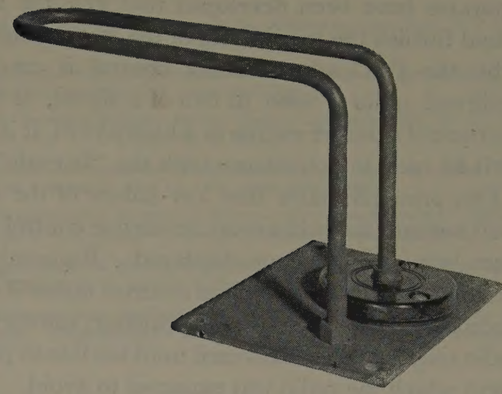


Figure 9. Three types of quarter-wave ground plane antennas for mobile stations

Figure 10 (right). Twin-skirt half-wave coaxial antenna

end-to-end phone communication permits the train crew to handle their train much more effectively, particularly under adverse weather and operating conditions. Time is saved in preparing a train for departure, when entering and leaving sidings, and at many other places en route where it helps to know just where the other end of the train is, so as to clear switches or road crossings—or to spot a crippled car that must be set out before serious trouble starts. The radio is used by the engineer and conductor to co-ordinate the brake pipe tests before a train leaves the yard. The engineer is notified when the flagman is aboard after the train has been stopped. Radio takes the place of hand signals and eliminates the need for fuses for hand signals under bad weather conditions. Without radio, it sometimes is necessary for the conductor of a freight train to stop the train by applying the brakes from the rear end because of some emergency of which the engineer is not aware, such as a bad hot box, or a fire in a car, or shifting loads. But with radio the conductor can talk with the engineer, and the train can be stopped from the head end thus avoiding the danger of a pull-apart that sometimes occurs when the conductor is obliged to apply the brakes from the rear end of a long freight train.

Train-to-train radio enables train crews to follow the progress of other trains in the vicinity. It is useful when two trains are approaching a meeting point. If the speed of the train that is to hold the main track is such that it will reach the point ahead of the train that is to take the siding the engineer can reduce speed and avoid stopping his train. Conversely, if he knows that the train to be met is already on the siding, he is able to approach the meeting at a higher speed. Radio also permits a train crew to warn another crew of any unsafe conditions that may be discovered when trains are passing each other. Similarly, information concerning unsafe wayside conditions can be given by radio to other trains and to the wayside radio stations.

Other uses of train to wayside, that is, point-to-train radio, are included in the following list:

1. Trains are able to obtain extra time to work in a block without someone's going to a wayside telephone to get permission.

2. The dispatcher is able to know the positions of trains in his radio territory and to plan his train orders to better advantage, changing his orders promptly to care for unexpected or emergency conditions.

3. Before a train enters the yard at the end of the division, the operator is able to give the train conductor the number of the yard track to which it is assigned.

4. Breakdowns can be reported immediately to the operator and the dispatcher so that appropriate action can be taken promptly. For example, when a draw bar pulled out on a car in a through freight train, the car was left on a siding and arrangements made by radio to have the local freight pick it up the same day. Without radio the local freight would not have been notified in time, and there would have been a delay of at least 24 hours in having the car moved.

## EQUIPMENT

The great importance of continued proper operation of railroad radio under the severe operating conditions encountered in railroad service has made it necessary to design and build new equipment that would be suitable to, and give the performance needed by, the railroads. The Association of American Railroads (AAR) has prepared a specification setting forth the requisites that must be met. In addition to these, the equipment also must meet certain requisites set forth by the FCC specifically in matters of frequency stability, frequency band width, kind of emission, and the amounts of radio-frequency power radiated.

The rigors of weather, vibration, and severe shock to which mobile equipment is exposed necessitate special housings with resilient mountings for the radio equipment. These housings are suitable for securing in any location on the exterior of locomotives, tenders, cabooses, tug boats, and so forth. Equipment at a land station occasionally is mounted in the outdoor type of housing but usually is housed in an indoor type of cabinet. If mobile equipment is to be mounted in a protected location, for example, inside the cab of a Diesel locomotive, a ventilated cabinet is frequently used, but it must provide protection from mechanical damage, shock, and vibration.

Frequently it is necessary to control a railroad radio station from two or more control points, both of which may be quite remote from the station where the transmitter and receiver are located. To do this, remote control circuits

and apparatus have been developed that give the needed control and furnish the monitoring of the station that is required by the FCC when remote control is employed. When railroad radio is used in lieu of a signal, as for example to control a pusher engine in a hump yard, it is essential that it be used in accordance with the "fail safe" principle. This principle states that any failure of the system shall result automatically in a more restrictive control or signal aspect being enforced or displayed. Railroad radio should not be used for so-called vital controls unless it can be used in accordance with the fail safe principle, since a failure of the radio might not be discovered until too late to prevent an accident which the radio was expected to avoid.

Figures 1–10 show some of the General Railway Signal Company equipment that has been developed for railroad radio service. The Type-*A* inductive carrier equipment consists of a narrow-band frequency-modulation transmitter and receiver for operation on 70 to 200 kc. The transmitter has an output of 35 to 40 watts for mobile units and two watts for wayside stations. It uses a deviation ratio of one to one, and is designed to be operated from a 117-volt 60-cycle supply. The Type-*A* receiver is of the single-conversion superheterodyne type and has a sensitivity of approximately three microvolts. It is equipped with a differential action squelch circuit and provides an audio output of five watts. The set, consisting of a transmitter and a receiver, draws approximately 130 watts when receiving and 270 watts (for a mobile station) or 200 watts (for a wayside station) when transmitting. At a mobile station the set is connected to a wire loop which is used for both transmitting and receiving. At a wayside station a capacitor usually is used to couple the set to the line wires of the railroad pole line.

The Type-*E* space radio equipment consists of four basic electronic units, that is, a frequency-modulation transmitter and receiver, a power supply, and a radio-frequency power amplifier to increase the output power from 10 watts to 50 watts when needed. The units have plug connectors for all connections except for the coaxial line from the antenna lead-in and radio-frequency connections between units. Multichannel operation is available for as many as four frequencies. All channels are crystal-controlled and may be selected by crystal switching without retuning, provided the frequencies are within a band not wider than 1.2 megacycles. The quick-detachable unit-type construction is employed to provide greater flexibility of application and ease of maintenance. Power input at 117 volts, 60 cycles, for the 10-watt station, is 170 watts for standby, 220 watts when receiving, and 235 watts when transmitting. The equivalent data for the 50-watt station are: standby 200 watts, receiving 250 watts, and 425 watts when transmitting.

The transmitter is designed for operation with several different types of hand-sets or microphones, or a talk-back speaker. It can be operated on frequencies in the range 158 to 162 megacycles. The receiver is operable over the same range of frequencies, and has a sensitivity of one microvolt or less, and a 5-watt audio output. A ratio type of squelch circuit is employed to silence the noise that is present in a high-gain receiver such as this one when no carrier is being received.

The power supply unit can be one of several varieties to meet various field conditions. The usual kind takes power at 117 volts, 60 cycles, and transforms and rectifies it to supply the various needs of the electronic units of the set. Another type is designed to be operated from 12 volts direct current, another for operation from six volts direct current, but in each case the transmitter and receiver remain the same. When the self-checking feature is employed, the additional equipment is mounted in additional units. The check unit at the wayside station contains the relays, the motor-driven code transmitter, and other apparatus used to transmit automatically the check pulses that operate the check system. The check unit at a mobile station contains the relays and associated apparatus used to display the check light in the cab of the pusher engine.

Many types of antennas have been tested by various railroads and manufacturers. They have nearly all belonged to the class of antennas that produce vertically polarized radiation. The problem of staying within established clearance dimensions has resulted in a rather general use of the quarter-wave antenna for mobile units. Variations of the basic quarter-wave design have been used to effect a reduction in height, increased mechanical strength, or a completely grounded antenna. Since wayside antennas are not usually subject to clearance limitations, it is possible and customary to employ a half-wave antenna or a multiple-element array to produce greater useful radiation per watt of power. Multiple-element arrays have been designed with vertical directivity characteristics but a circular horizontal pattern to provide an improved general coverage; others have employed horizontal directivity to concentrate radiation in one or more particular horizontal directions. Combinations of horizontal and vertical directivity have been tried to produce maximum signal strength in one or two directions.

Yard engines are relatively small and therefore do not ordinarily present serious problems in finding a suitable place in which an antenna can be mounted. There is usually room within the clearance limits to mount a standard quarter-wave antenna or even a dipole coaxial antenna. Main-line locomotives, however, present questions that have not been fully answered. The fundamental problem is to get an antenna that is short enough to permit mounting on a locomotive within very close clearance dimensions and at the same time, not to sacrifice too much in efficiency of operation. One of these is about seven inches high.

## TYPICAL RESULTS

The results that are being experienced by railroads using radio include the following items:

1. The work of train crews is facilitated.
2. Safety is enhanced by eliminating unnecessary stops and stops made by applying the brakes from the rear end of the train.
3. The work of the crew members is better co-ordinated which tends to promote safer operation.
4. It has been found that in using end-to-end railroad radio, engineers and conductors have developed a greater respect for, and understanding of each other's problems.
5. Time is saved en route and in departing from and entering terminals.

6. More cars can be handled in a given time in hump yards, and railroad tugs are able to do more work in a day.

There are many known instances[2–8] in which railroad radio has increased efficiency, avoided delays and promoted safety, and before long, the railroads should have sufficient data from which to show accurately the savings that can be made by its general use.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# Career Opportunities in the Utility Field


FRANK E. SANFORD
FELLOW AIEE



**The feeling that the utility field does not offer opportunities for the electrical engineer is a mistaken one. Not only are the opportunities numerous but a survey of the industry reveals that the top positions in the industry are held by electrical engineers. In addition, the steady growth of the utilities industry offers more and more openings in this field.**


ALTHOUGH the major decisions of choosing a career have been settled before a student obtains his degree as an electrical engineer, he still has several divergent paths open for his next step. In the distance, along the road he chooses, he would like to see signs of advancement possibilities, with speed measured by personal abilities, and with room at the top. He wants to be in an industry that has promise of continued growth, with new frontiers for development. He hopes that personal stability and security will follow along with personal prestige and satisfaction.

Electrical engineering graduates of the next ten years who carefully consider these factors will find exceptional career opportunities in the electrical utility field. From the vantage point of a training period they will see a wide field for application of their technical knowledge. Perhaps even more important, they will find many parallel paths within the industry for the best use of their individual abilities and aptitudes.

## ADVANCEMENT WILL BE FAST

For these young engineers, opportunity for advancement will be added as an attraction above the traditional stability and security of utility employment. They will take part, during the years they are reaching the peaks of their engineering abilities, in building the electric systems to several times their present capacities. From among them, the top engineering and executive positions will be filled, while they are in their forties and early fifties.

This conclusion is contrary to an impression which frequently tends to discourage the most desirable students from seeking a career in the electrical utility industry. While this impression of advancement may be derived from experience in the past 15 years, it is refuted by analysis of the present situation and its projection into the next 15 years.

An idea of the requirements for young engineers in the utility field is shown in Figures 1 and 2, which were published in *Electrical World,* May 10, 1947. The starting point is the 1946 line showing age groups of engineers now employed, based on information from a representative list of companies. This is reflected to show the rate of employment and projected to show the normal retirement expectancy. This retirement rate, plus an allowance for attrition due to other causes, gives an estimate of new engineers needed to maintain the present engineering personnel. No allowance was made for overcoming the present shortage, or for increasing the engineering forces to meet increased requirements.

Three principal conclusions were addressed to the attention of utility engineering executives:

1. The electrical utilities must employ three times the number of young engineers in the next 15 years that they have employed in the past 15 years if they are to maintain their present engineering personnel.

2. Between now and 1960, there must be added to the engineering staffs 50 men for every 100 now employed.

3. The rapid growth of the engineering group in the decade 1920–30, with a drop in the rate during the following decade and a virtual standstill in employment during the war period, will be reflected in the future rate of retirement.

The corollary conclusion, from the viewpoint of the graduate student who enters the utility industry in the next few years is that by 1960, one-half of all the present engineering positions in the utilities must be filled by the students or young graduates of today, with 10 years or less of experience. All but 20 per cent of the engineering personnel of 1970 will


Full text of a conference paper recommended by the AIEE education committee and the AIEE committee on Student Branches and presented at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948.



**Frank E. Sanford** is director of research and development, Copper Wire Engineering Association, Chicago, Ill.

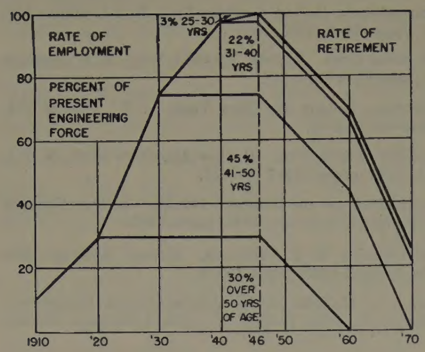



**Figure 1**

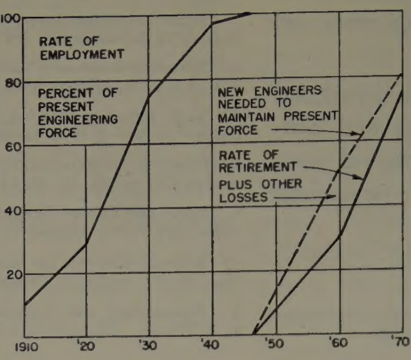



**Figure 2**

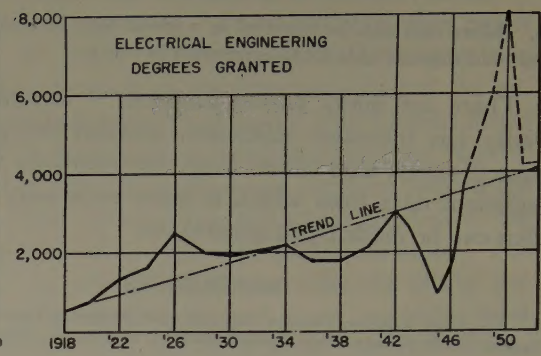



**Figure 3**

be from this younger group. Five years later, when most of them are still in their forties, they will have just about all of the responsibility.

## GROWTH IS BASIS OF STABILITY

Electric power—generation, distribution, and application—has had a continuous growth, both in capacity to serve and in energy sales. The rate of increase has varied some, but the fact of an increase in every year is notable through the period spanning two wars. There is every indication that the industry will continue that record with no let-down in the predictable future.

One long-range projection, considered to be conservative, is on the premise that the rate of growth in the next 30 years may be only one-half that of the past 30 years. That would require engineering plans for an industry five times as large as at present. Plans to meet power requirements on the basis of a 50 per cent increase in five years or of 75 per cent increase in ten years are in the shorter range predictions.

Stability, as it is applied to the electrical utility experience, describes a condition of continuous growth rather than the mere absence of severe ups and downs. It is the continued need to solve engineering problems and to plan new construction that makes the utility type of stability so favorable for the engineers. The plant is never finished to settle into a routine operation.

## TREND TOWARD POWER INDICATED

It is well known, both in the engineering colleges and the electrical utilities, that electronics is a serious competitor of power for the interest of electrical engineering students. Choice of elective subjects as well as response to employment interviews have been reported to show the overshadowing of the power business in the minds of postwar students.

A searching analysis of this situation and the weak points in the utility industry appeal were placed before members of the Edison Electric Institute a year ago. Training programs, starting salaries, interview methods, and other factors have been considered extensively by individual companies and by a special industry committee during the past year. This long-range viewpoint, with careful study and planning for the future years rather than for the immediate year, is typical of well established industries. Career opportunities are greatly enhanced by this approach, and the immediate prospects are much better with the programs that have been adopted.

In general, the electrical utilities have not had postwar critical shortages of engineering personnel that were of immediate concern. This is in contrast to some of the newer industries which have been under pressure to build organizations almost from scratch. The longer view of a five- to ten-year-employment program to build experience for future needs has been in competition with the more urgent needs, in a supply that has been itself short.

The numbers of graduates—the supply in this consideration—has been increasing rapidly in the past three years. Undoubtedly, every engineering educator and student is aware, from the daily rubbing of elbows if for no other reason, that the graduating classes of the next three years will set new records. The analyses which have been made indicate, however, that the demand and supply will just about balance in the present postwar period. This conclusion for all engineering branches appears to be particularly true in the case of electrical engineers.

The curve of electrical engineering degrees shown in Figure 3 is based on data of the American Society for Engineering Education. The section of this curve for earlier years was plotted by applying electrical engineering student percentages to the totals for all graduates. The present and estimated sections, for the years to 1951, are based on registration figures reported for November 1947.

It is of interest that electrical engineering students have varied only from 18 to 21 per cent of the total engineering students throughout this period, with two notable exceptions. The ratio went up to 32 per cent in the period after World War I and it reached a low of 15.4 per cent in 1940. The expected rush of veterans into electrical engineering has not developed in the present enrollments. With a deficit below the trend line for all engineering graduates greater in electrical than in the total engineering degrees, the general conclusion that the present peak will average with no surplus is especially applicable for electricals.

There is a further significant conclusion, however, for the present electrical engineering students, when the facts of this curve are combined with consideration of the recent most urgent demand and the longer view of the future in power.

Immediate needs of the newer industries are becoming less and replacement needs of the older industries are increasing. The ratio of employment opportunities is undoubtedly changing at the same time the number of graduates is rapidly bringing a closer balance with the total field of employment.

Being realistic will mean for many thousands of these students that 60-cycle interests also should come into a closer balance with higher frequencies in their preparations and career ambitions. They will plan careers on the basis of lasting individual satisfaction rather than any temporary advantage or fascination. They will take the longer view of combining tradition, stability, and growth with good solid interest in a wide variety of individual opportunities and channels of specialization.

### EXPERIENCE BASIS FOR SPECIALIZATION

It is in helping to shape still another step in a career that the electrical utility offers a most unusual inducement. The range of fields for the application of technical knowledge and experience is almost without parallel in any other industry. Aptitudes and abilities can be judged in experience as a basis for further special efforts. That they are important for success in the work chosen is well known.

While some tests for interests and reactions have replaced reading palms and examining head shapes, this knowledge is still not in the same class with mathematics or the physical sciences. There is a lot left for personal experience and for trial and error in finding the spot most conducive to results and contentment, which is a major factor in success and advancement. Design, selling, analysis, operation offer a wide range in these specialized opportunities in the electrical utility.

This may not fit in with the conception which is easily obtained from the necessary subjects of study in preparing for the electrical engineering degree. Solving 60-cycle voltage problems may look drab for many graduates by comparison with some of the other applications of engineering. As a matter of fact, although this type problem is fundamental to all others, only a small percentage of the utility engineers are concerned with the solution of these problems in their daily work. And there is no lack of a frontier for this group. System interconnections, stability, higher voltage transmission, capacitor applications, and fault conditions are but a few of the subjects for further development. Lightning has been solved but corona and short circuits linger on.

Many more engineers are concerned with distribution. Layout of a new feeder is rather on the routine side today, but there is still the solution of a system for double and then up to five times the present load density. Will it be at higher voltage, by networks or by some new conception or combination? Aerial cable distribution will replace open wire in many sections, but few installations are beyond the trial stage today. Substation design is undergoing a drastic revision. Automatic controls, remote supervision, and relaying problems need some more application of high-frequency knowledge—a place for electronics.

Nuclear energy sometime may be a factor in power generation in large central stations. It is a fascinating idea. Meanwhile, though, the hydro and steam turbine plants must be built to about double the present capacity in the next ten years, and then go on to double again. Design problems involved will challenge a great many good engineers.

Perhaps all of the design and operating problems fail to stimulate sparks in the young engineer's mind. Perhaps he should turn to load analysis and prediction. Almost entirely a new science in the realm of engineering and statistical analysis, load research now is approaching the must-have stage in utility organization. Analytical study of load components and load-type characteristics is necessary for rate development, for predicting investment requirements, and to guide management and sales programs. Simple kilowatt and kilowatt-hours data are no longer a match for the load pattern of modern industry. It is a new frontier for engineers with imagination to jostle their mathematics.

At about this point the engineers who lean toward what the psychologists call the salesman type may lose interest. They may not be as careful of details, or calm and reserved, or as subjective, as the fellow who does best in the design office or laboratory. They want to get out and make friends and influence people, and about one-half of all the engineers in the utility industry must do that every day, either in supervisory positions in construction and operation or in the sales or commercial departments.

Selling electric power and designing lines are actually not far apart in their basic engineering requirements. Power is sold to business and industry by suggesting and proving the economic application of new machines and processes for individual customers of the electrical utility. Specialists in power application must be acquainted with problems in the fields of machine tools, paper making, chemical processing, and many more. They must know of the new developments in heat treating, steel fabrication, conveyor systems, all of which save other costs by using electric power. That is the keynote to increasing production, with lower costs and higher quality, which is also an essential characteristic of engineering.

### ENGINEERS GO TO TOP SPOTS

Within the broad field of which the utility cadet training program is the center, we find many divergent paths. The young engineer may follow out the path of mathematical ability, apply an analytical bent, or his personality traits. He may seek a quiet corner for network analysis or stability problem solutions, or he may turn to the big outdoor jobs on construction. He will find the keen activity of emergency operations interspersed with the long view of planning years in advance.

Beyond these important openings for individual aptitudes there are other opportunities in the top spots for superior management abilities, with no ceiling for engineers in the organizations. About three-fourths of the men at management level started in the technical divisions, and of the 25 largest utility systems in the United States, 12 are guided by presidents who started as engineers. The trend is in this direction. Six of these presidents who have taken this office in recent years are engineers. Their backgrounds in professional attainment include a leading authority on transmission line operation, an outstanding distribution engineer, and a leader in applying the engineering viewpoint to commercial problems.

Electrical utilities are engineering businesses and they offer good opportunities for engineering careers.

# Polyethylene-Insulated Coaxial Cable

H. B. SLADE
ASSOCIATE AIEE

F. P. WEST
ASSOCIATE AIEE

A 138-kv underground oil-filled cable power circuit, recently installed between the Sherman Creek generating station of the Consolidated Edison Company of New York, Inc., and the Dunwoodie substation of the Yonkers Electric Light and Power Company 8.1 miles away, needed an underground carrier current circuit to tie-in with the carrier current circuit superimposed on a 138-kv overhead line from Dunwoodie to Millwood, a distance of 21 miles. The two power circuits are connected at Dunwoodie and the 60-kc carrier circuit controls high-speed directional relays which protect the power circuits. The cable for this circuit is installed in the same underground system with the power cable and terminates at the same stations. The carrier transmitting and receiving equipment required a cable with approximately 70-ohm characteristic impedance and with an attenuation within specified maximum limits at frequencies from 50 kc to 150 kc. A coaxial cable consisting of a number 13 stranded copper conductor, 185 mils of polyethylene insulation, a woven copper braid shield, and a 78 mils thickness neoprene outer jacket was selected.

In planning the cable joints, the greater attention was given to the formation of a solid section of polyethylene bonded to the insulation of each cable end, offering no chance for moisture to enter causing failure or change in characteristics of the cable. Finding the adhesive type of polyethylene splicing tapes somewhat inferior because of water seepage, a molded polyethylene joint was chosen as the best for this service. To avoid the chance for electrical reflections from frequent and irregularly spaced splices of different surge impedance than the cable proper, it was decided to keep the spliced conductor as near the same size as the cable conductor as possible by scarfing the conductor ends in a die (Figure 1) and using a split aluminum forming clamp (Figure 1) to hold the ends in position while soldering.

The mold is made of steel (Figure 1) in two halves with cooling fins at the two ends to prevent heat applied along its center portion from being conducted away from the center to a distance sufficient to melt the cable insulation at the ends of the mold. A hole was drilled at the bottom center of the mold for insertion of a thermocouple to control the temperature within the desired limits. A pressure relief vent was provided in the top center of the mold to prevent excessive pressures from developing during heating.

After the cable ends had been prepared and the conductor sweated together, a section of cable insulation previously cut to length and slit on one side was placed over the exposed conductor. (See Figure 1.) The mold was placed in

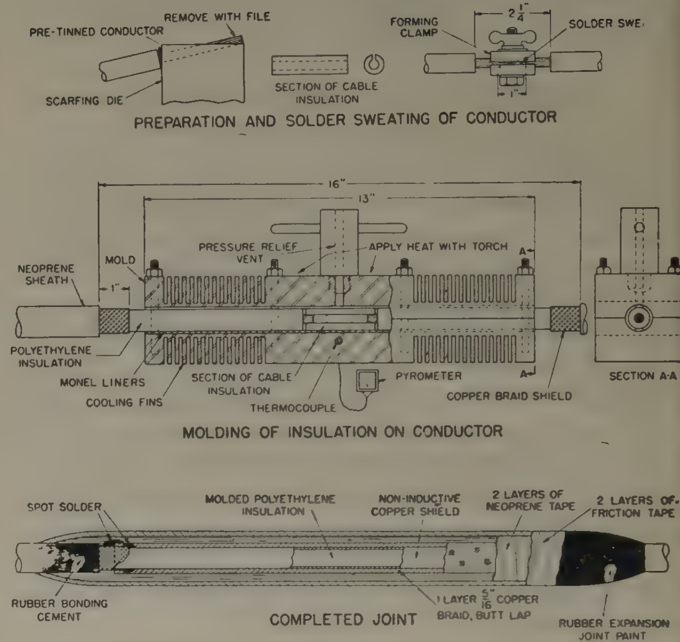



**Figure 1. Joint for the polyethylene-insulated coaxial cable**

position and tightly clamped around the cable with two 5-mil thickness monel longitudinal liners placed over the inside intersection of the two mold halves on each side to prevent the insulation from flashing out at these points. These liners distributed the heat more uniformly so as to prevent voids from forming in the insulation during the molding process. Heat was applied with a torch along the center portion of the mold at temperatures between 240 degrees Fahrenheit and 250 degrees Fahrenheit for a period of 15 minutes. After completing the molding process, the joint was completed with a shield and tape covering. The shield consisted of two overlapping copper tapes laid longitudinally along the cable between the ends of the cable shielding braid over which was spirally wrapped a copper braid. The tape covering consisted of two layers of neoprene tape applied half lap over the shield and ends of the sheath and two layers of friction tape applied over the neoprene tape with a covering of protective paint.

Two coaxial cables, one for a future circuit, were installed in one of the 5-inch precast concrete ducts without apparent damage. In some cases the cable was pulled through manholes and racked without joints. Joints were made without difficulty except voids were found in the surface of the molded polyethylene in several joints after molding. In trying to determine the reason for the voids, evidence pointed to moisture condensed on the inside of the metal mold before its use as a possible cause. Twice during and after splicing the two cables were tested for attenuation. At 60 kc, in all cases the losses were found to be 0.28 decibel per 1,000 feet. In comparison with cable tests made in the factory, splicing did not increase the losses of the circuit.

Digest of paper 48-253, "Polyethylene-Insulated Coaxial Cable for Carrier Current Control Circuit," recommended by the AIEE insulated conductor committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**H. B. Slade** is a research engineer with The Okonite Company, Passaic, N. J. **F. P. West** is assistant engineer with the Consolidated Edison Company of New York, Inc., New York, N. Y.

# Compass Compensating Coils

R. A. ROBINSON

JUST at the critical time when submarine wolf packs and magnetic mines were sinking Allied ships faster than they could be constructed, merchant ship strandings and collisions were reported to have been caused by the effect of degaussing coil fields on the magnetic compass. The installation of compass compensating coils permitted the immediate and satisfactory resumption of navigation by magnetic compass.

"Degaussing" refers to the countermeasure for reducing a ship's external field in order not to detonate a magnetic mine. The vertical component of a ship's field at a particular depth beneath a ship is neutralized (or reduced) by means of current-carrying loops of cable (degaussing coils), suitably arranged within the ship.

Although magnetic compasses are the principal instrument of navigation on many merchant ships, the subject of magnetic compasses is not as familiar to electrical engineers today, as it was a few years past, when they were employed as the principal navigational instrument of naval vessels and merchant ships. A slight review of magnetic compass theory therefore is presented first as a background for compass compensation for degaussing.

Magnetic compasses normally are fitted with two types of correctors, permanent magnets and soft iron correctors. The magnets permit adjustment for the effect of the permanent magnetism in a ship's hull and machinery; soft iron correctors provide correction for the induced magnetism. Deviations due to the ship's permanent magnetism are called semicircular (magnitude varies sinusoidally or cosinusoidally with the heading of the vessel). Deviations due to induced horizontal magnetism are termed quadrantal (magnitude varies as the sine or cosine of twice the angle of heading). Higher harmonic errors (sextantal and octantal) are rarely present if compass magnets are arranged and magnetized properly. When present, they are caused by soft iron or permanent magnets (usually corrector magnets) too close to compass needles.

Normally, the compass deviation due to degaussing is semicircular, provided the degaussing coil current is kept constant. Precise compensation is attained by using three mutually perpendicular sets of coils, suitably arranged about the magnetic compass. Any desired magnitude and direction of compensation is obtained by setting the proper currents into the three component windings, using suitable control resistors. Continuous compensation regardless of degaussing current setting is accomplished by obtaining the compass coil power supply from across a series resistance in the degaussing coil circuit. One set of windings is required for each degaussing coil affecting the compass.

When very strong degaussing effects are compensated at the magnetic compass, three factors may cause large harmonic deviations, namely: improperly magnetized compass needles; nonuniform compass coil magnetic field pattern; and nonuniform degaussing field at the compass needles. Since the harmonic effects are still present after the fundamental semicircular effects are compensated, they assume major importance if the initial degaussing effect is large. For example, $7^1/_2$-per cent sextantal effect could be tolerated in the case of an initial 15-degree degaussing effect ($1^1/_8$ degrees) but $7^1/_2$ per cent of an initial 50-degree degaussing effect would cause a $3^3/_4$-degree sextantal deviation making the compass unreliable. As an example of what can happen with an improperly matched compass and compass coil combination, the steering compass on one vessel exhibited eight degrees uncorrectable deviation until the compass magnets were altered, bringing the asymmetrical deviation down to one degree.

Interaction between components as a result of proximity of compass coils to soft iron correctors is an important design problem. When coils are mounted fore and aft and athwartship, their proximity to quadrantal spheres and Flinders bar causes these soft iron correctors to function as cores, or in some instance they even become permanently magnetized. Under such conditions, degaussing compensation is affected whenever the size or position of these soft iron correctors is changed. Following are the major design considerations in obtaining the required accuracies:

1. Provide maximum separation between compass coils and soft iron correctors by mounting the compass coils on intercardinal axes displaced 45 degrees from the cardinal axes where soft iron correctors are mounted.

2. Secure all three sets of coils rigidly in one assembly to ensure that components remain mutually perpendicular.

3. Employ short compass needles with low magnetic moment in preference to long-needled compasses with strong magnetic moment.

4. When weight and space considerations permit, return-field compensation is employed for horizontal compensation in preference to direct-field to obtain greater uniformity of magnetic field.

5. Where a pair of coaxial coils is employed to furnish horizontal direct-field compensation, exploration of the space immediately above or below the mid-position of the coil axis often results in a usable area of greater field uniformity without excessive decrease in field strength. Placing the compass needles at this relative elevation results in fewer harmonic deviations or "fringe" effects from the coils.

6. Where practicable, the compass coil supply feed is obtained from across a nichrome series resistance in the degaussing coil circuit, rather than across a portion (or all) of the degaussing coil in order to take advantage of the lower temperature coefficient of resistance across the nichrome. This condition is improved still further by keeping the compass coil resistance low compared with the control resistance so that any change in compass coil resistance with temperature is small compared with combined resistance.

Digest of paper **48-228**, "Compensating Effects of Degaussing Coils on Shipboard Magnetic Compasses by Use of Compass Compensating Coils," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**R. A. Robinson** is an electrical engineer in the electrical branch of the Bureau of Ships, Navy Department, Washington, D. C.

# Dummy Loads for Large Industrial Welders

A. W. BROWN
MEMBER AIEE

S. E. JOHNSON
ASSOCIATE AIEE

**A solution to the problem of objectionable voltage fluctuation in large industrial welders can be brought about by electronically interlocking each single phase welder with a dummy load to fill in the period of no load between welds; the load to be of suitable magnitude to keep the voltage variation within allowable limits. In addition, this method also results in considerable reduction in kilowatt-hour consumption of ballast load.**

DURING the recent war an industrial plant operated by the Conco Engineering Works at Mendota, Ill., obtained a contract to fabricate water cans for the United States Marine Corps from 0.052-inch *S* sheet aluminum. The practical method of fabrication required making 20-inch longitudinal welds and similar circumferential welds to attach end covers. Reliable data on seam welding of aluminum were limited and production had to be started in a matter of about four months. Continuous application of heat to the seam weld not being practical because of advance heating of the material, the welders selected were equipped with electronic timing and phase shifting heat control with current turned on and off in a predetermined recurring sequence. In this instance, sequences selected were two cycles on and six off for top and bottom circumferential seams and three cycles on and five off for longitudinal seams.

This frequency of $7^1/_2$ fluctuations per second, considering only voltage dips, was at the most objectonable frequency according to published curves relating allowable voltage fluctuations to frequency of their recurrence. These curves indicated that more than 0.4 per cent fluctuation affecting other customers on the same electric system would be objectionable.

The problem was complicated further by uncertainty as to actual demand of the seam welders when placed in operation, as the welder manufacturer lacked experience and design data from which to predict kilovolt-ampere and power factor of the welder load. The industrial plant was located in a city of approximately 4,000 population supplied over a 34.5-kv transmission line 28 miles from the generating station of the Illinois Northern Utilities Company, and remote from other large industrial loads. This particular welding load unfortunately was proposed at a location distant from the power source where capacity for handling industrial loads of this type had not been provided.

For fabricating aluminum, the welder manufacturer had estimated the required single phase input to each welder to be 200 kva, even when equipped with series capacitors for correcting the power factor to 95 per cent lagging. The Conco Engineering Works previously had welded steel cans using seam welders equipped with series capacitors to reduce kilovolt-ampere demands and limit voltage fluctuations to values which would not cause objectionable interference to lighting or nonstandard operation of other equipment used by general customers supplied from the same transmission system. Based on the previous experience with the welding of the steel cans, the Illinois Northern Utilities Company's engineers advised the customer that the proposed seam welders for aluminum with an estimated instantaneous demand of 200 kva each at 95 per cent power factor would cause voltage fluctuations intolerable to thousands of other customers.

Because line materials could not be secured in the short time available, and because increasing the capacity of the transmission line was not economically feasible for this temporary load, it was clear that some different method of reducing welder demand or voltage fluctuation would be required.

## METHODS OF LIMITING FLUCTUATION CONSIDERED

One direct approach which would appear to be effective in reducing demand of a device whose function is to put heat into material would be lengthening of heating time or, in this case, increasing welding time. This is not practical in seam welding of aluminum because the heat of fusion must be localized, the total weld consisting of a series of accurately spaced stitches, and the heating period of each stitch must be very short to prevent heating of excessive area. The welder manufacturer was certain that approximately 40,000 amperes would need to flow through the material being welded which would require about 200 kw input to the welder transformer, considering five volts as minimum secondary voltage even with clean contacts and material. Also, economy of production time required highest practical speed of material travel between welder wheels.

Shunt capacitors, while extensively used for supply of reactive kilovolt-amperes to offset reactive kilovolt-amperes of inductive loads, were not seriously considered for this application. With a very highly intermittent load of the nature of these welders and with the capacitors connected in parallel with the welding transformer, the current inrush to the shunt capacitors each time the circuit was energized would have increased the voltage fluctuation.

Equipping the proposed seam welders with series capacitors was known to be entirely feasible and effective in reducing the reactive component of demand. The welder transformer input would have been at about 35 per cent

Full text of paper **48-293**, "Dummy Loads Applied to Large Industrial Welders to Reduce Voltage Fluctuations," recommended by the AIEE industrial power systems committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

**A. W. Brown** and **S. E. Johnson** are both with the Illinois Northern Utilities Company, Dixon, Ill.

power factor without series capacitors, resulting in approximately 540-kva input for 190 kw delivered to the work. Equipping the welders with series capacitors to make an input power factor of 95 per cent and to reduce kilovolt-amperes demand to 200 appeared feasible. However, this reduction in demand was not sufficient as previously mentioned, as the resistance component of drop in the transmission line would have resulted in excessive voltage drop. The apparent reduction in voltage drop which could be obtained by adding sufficient series capacitors to correct to a leading power factor seemed a likely solution. However, the electronic control engineers ruled this solution out for several reasons.

In the first place, phase shifting heat control introduces certain transient phenomena which cause the current to vary from sine wave form. The resulting voltage drop on the phase to which the welder is connected then may be greater than at unity power factor and voltage in other phases of the supply circuit may rise or fall depending on the amount of time delay in firing the ignitron contactor.[1] Secondly, leading power factor operation, according to the control engineers, may lead to instable operation of the phase shifting heat control equipment. Also, because slight variations in contact pressure and in material resistance are much more detrimental in upsetting welding current control at or near unity power factor than where reactance is appreciable, the welder manufacturer would not agree to design the welder-capacitor combination for performance at higher than 95 per cent power factor.

The use of a motor-generator set would have spread the single phase load of each welder over three phases and induction motor drive would have reduced instantaneous demand through flywheel effect. Disadvantages ruling out this solution were the high initial cost of the motor-generator equipment and long delivery obtaining on large rotating machinery of this type during World War II. Motor-generator sets would have been more applicable where a larger number of welders were involved so that the rotating equipment could be smaller in proportion to total connected load because of diversity in the welder demands.

Interlocking of the welders to prevent simultaneous operation would have reduced production and was not a solution since operation of one welder caused excessive drop in the 34.5-kv transmission line.

## SOLUTION SELECTED

The welder manufacturer's engineers suggested that the period of no load between welds of each welder be filled in by a dummy load of suitable magnitude to reduce voltage variation to allowable limits. For example, with a sequence of two cycles weld time and six cycles off, electronic timing equipment could be used to apply a load large enough and for the sole purpose of holding voltage change within prescribed limits of less than 0.4 per cent. The dummy load could be smaller than the welder load since some difference in drop caused by the two loads could be tolerated as long as the difference was less than about 0.4 per cent. Another advantage readily apparent was the availability of materials for constructing either an inductive or resistance type of dummy load and at reasonable cost. Soon after the dummy load was suggested by the Sciaky Company engineers, a meeting of welder design engineers, General Electric Company control application engineers, and Illinois Northern Utilities Company engineers, was held to discuss the details of the method.

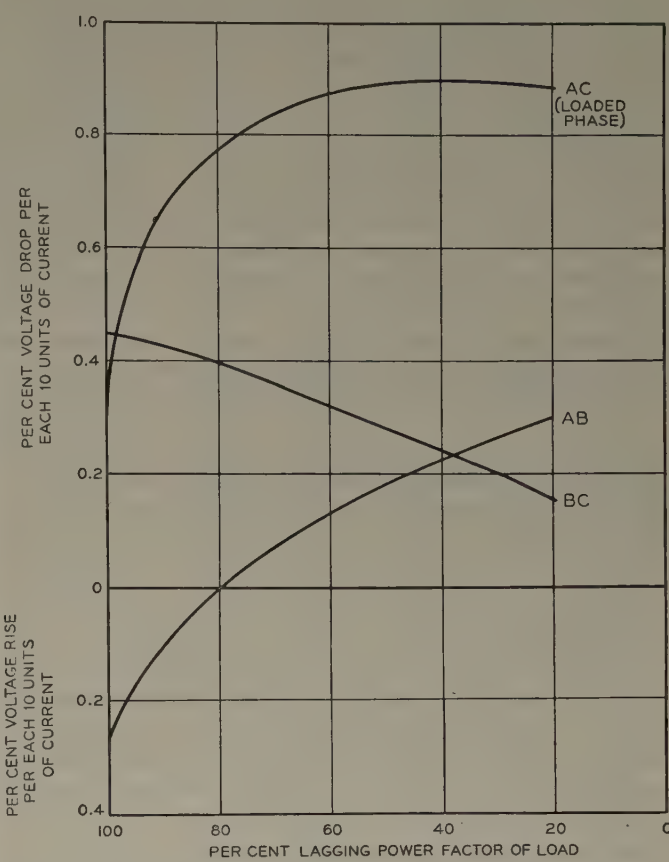



**Figure 1. Voltage change in 3-phase transmission line and transformer bank due to single phase load**

The conference in Chicago resulted in the following points of agreement:

1. Dummy loads previously had been suggested for reducing fluctuations due to welders but, to the best of the knowledge of the group, had not been applied through electronic control anywhere in the United States. The control application engineers could see no reason, however, why these loads could not be electronically timed and controlled to fill in the "off" cycles of demand between welds.

2. With allowable voltage variation on the 34.5-kv line supplying this factory and other loads being as small as 0.4 per cent, the welders should be series-capacitor-equipped to operate with estimated 200-kva demand rather than 540-kva without capacitor correction. The operation without correction would have required much larger dummy loads and very accurate matching of dummy load to welder both in quantity and in power factor. As actual operation later showed, the welder demand and power factor were not accurately known at this time.

3. With series-capacitor-equipped welders operating at an estimated 95 per cent power factor, dummy loads would need to be so constituted as to operate at nearly the same power factor. The use of a highly inductive load, apparently effective in causing the desired drop

in transmission line voltage, was more desirable from the viewpoint of less wasted energy since the resistance component of the dummy and consequently its kilowatt-hour consumption could be reduced greatly. However, consideration of the voltage changes in phases other than the one to which a particular welder and dummy were connected indicated the necessity for caution in selecting a dummy load of radically different power factor than the welder load. Figure 1 indicates the per cent voltage drop in each of the three phases of the 34.5-kv transmission line and transformer bank supplying the line for varying power factors. The current selected in plotting these curves corresponded to a 345-kva demand of each welder. A 62-kva dummy load of 40 per cent power factor would have limited the difference in drops due to 200-kva welder and dummy to less than 0.40 per cent on loaded phase *AC*, to 0.16 per cent on phase *AB*, and to 0.21 per cent on phase *BC*. However, the actual welder load turned out to be 315 kva as will be explained later, and considerably more dummy load would have been required. A condition can occur for larger welder loads where a dummy load of proper size to limit difference in drops on the loaded phase to proper value, will not limit the difference between drop due to high power factor welder and to low power factor dummy to this value as can be seen from Figure 1.

4. The most readily available type of dummy load appeared to be wire-wound resistors with air circulating fans. This load had the advantage of simplicity in design and rapid adjustment of quantity.

The major portion of the actual dummy load selected consisted of 140-kw units interconnected with each welder, this being the quantity calculated as necessary to reduce the difference in voltage drop caused by welder load and by dummy load to less than 0.4 per cent. Each dummy load was equipped with an electronic timer and interconnected with a welder so that the resistance ballast load was on for the 5- or 6-cycle period between stitch welds and also was on for longer periods while the operator handled material or stopped welding for short periods for other reasons. The dummy loads and associated controls were mounted on a steel superstructure with expanded steel floor grating above the welders. Most of the heat from the resistance ballast loads was dissipated in heating the surrounding air and proved to be so great as to require venting to outside atmosphere to prevent overheating of control equipment. Some of the dummy ballast consisted of immersion heaters used in heating fluids for other factory processes.

The wisdom of selecting dummy loads of flexible size became apparent when welding operations were started. Satisfactory welds at adequate production speeds on the six seam welders could not be had with the 200-kva input at 95 per cent power factor used in design estimates. Actual operating characteristics of the welders on clean aluminum sheets proved to be 315 kva at 87 per cent power factor lagging.

Obviously the 140-kva dummy loads were then inadequate, the difference in transmission line drops between welder and ballast loads being 0.88 per cent. Flicker affecting other customers was intolerable but production for war had to go on. The thermal capacity of the ignitron electronic control equipment for each dummy load being inadequate for handling approximately 300 per cent more ballast load required to match the 62.5 per cent greater welder load at lower power factor, extensive and costly changes seemed indicated. However the electronic control engineers saved the day with a novel and heretofore untried arrangement of electronic timing equipment. Why not, it was suggested, interlock two of the welders and combine two dummy loads in parallel on one phase with timing so arranged that one welder would be on two or three cycles depending on required welding time, then another welder would be on during the next two or three cycles, with the combined 280 kw of dummy load on during the remaining "off" period of four or two cycles? Frequency of voltage fluctuation then would be cut in half and quantity of flicker considerably reduced both because of the greater effect ballast load, and because two welders operated from one control could not be on simultaneously.

Another advantage to the welder user would be approximately 45 per cent reduction in kilowatt-hour consumption of ballast load during full scale welding operations since one welder would act as a ballast for another on the same phase for a portion of the time formerly taken up by the dummy load.

The scheme suggested by the electronic control engineers was approved by all concerned and the details of necessary alterations in control equipment soon were worked out. The control engineers decided to use the control of one welder with its associated electronic timer as the master control for itself and the other welder and 280-kw ballast load on the same phase. By placing extra actuating contacts in the synchronous timer of the master welder, the two welders and combined dummy loads were readily interconnected to work in proper sequence.

The 280 kw of dummy load obtained by combining two of the original ballast loads was not adequate to reduce voltage fluctuation to the 0.4 per cent considered necessary and desirable to avoid objectionable flicker. However, for the duration of the wartime contract for the particular welding operation in question, the greater fluctuation was tolerated.

## CONCLUSIONS

1. A dummy load switched by electronic control can be used successfully to limit voltage variation resulting from the operation of seam welders or other similar loads of known fixed quantity and power factor.

2. Where the voltage fluctuation caused by the recurring welder load considerably would exceed allowable values, the power factor of the welder circuit should be corrected by the use of series capacitors.

3. Caution should be observed in selecting a dummy load of radically different power factor than the welder load involved, and voltage drop in all three phases at the power factors involved should be considered, selecting the dummy of lowest power consumption for adequate loading.

4. The successful switching and interlocking of welders and ballast loads through electronic timers and ignitron controls proves the reliability, accuracy, and versatility of electronic control equipment when properly applied by control engineers.

5. Dummy loads appear to have appreciable promise in successfully supplying welder demands in excess of capacity of the supply system, particularly if the power consumed in these dummy loads can be utilized in heating of liquids or other industrial heating processes.

## REFERENCES

1. Voltage Changes Caused by Resistance Welding Loads, **I. B. Johnson, H. A. Peterson, C. M. Rhoades, Jr.** AIEE *TRANSACTIONS*, volume 66, 1947, pages 664–76.

# Shipboard Degaussing Installations

NICHOLAS B. MICHEL

EARLY in World War II the German Navy and Air Force started to lay a new type of sea mine, reputed later to be the first of the "secret weapons." This mine was detonated at a distance beneath a ship by the ship's influence rather than by actual contact as was necessary for previous types of mines. Due to the mystery surrounding the means of operation of this mine and the lack of countermeasures, it was a threatening weapon to Allied shipping.

As a result of the use of this mine the United States Navy set forth on an extensive program of reducing the magnetic field of its ships by the use of demagnetizing or "degaussing" coils. This program involved fitting approximately 12,000 naval and merchant ships with coil installations which along with the mine sweeping program, were successful during the war in affording such protection that the losses from this type of mine suffered by our ships were small. The most widely used form of degaussing was the permanent degaussing installation which was made on these vessels by the United States during the war.

This installation consisted of large coils of cables located within the hull of the vessel and equipment to control the intensity of direct current in the cables. The cable installation consisted of a group of electric current loops. These loops were located so as to produce a magnetic field approximately equal and opposite to the magnetic field set up by the ship. The effect of the "ship's field" is therefore materially reduced.

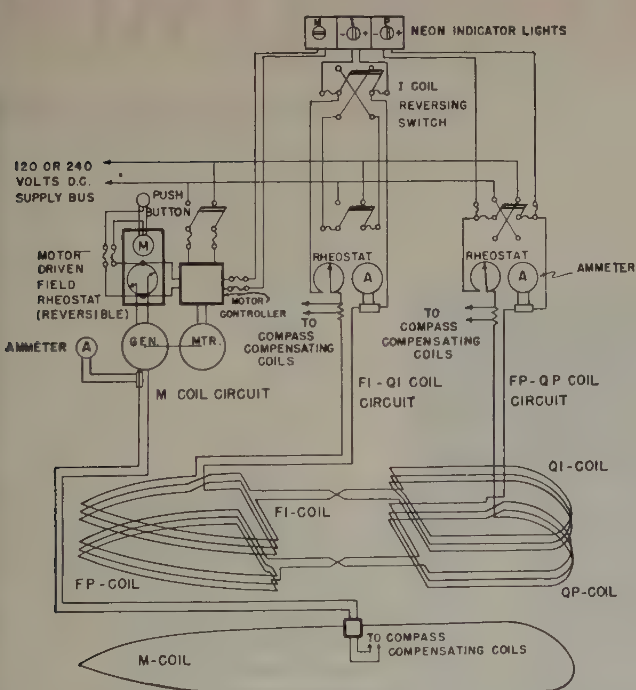



**Figure 1. Typical wiring diagram for degaussing installation using single and multiconductor cable**

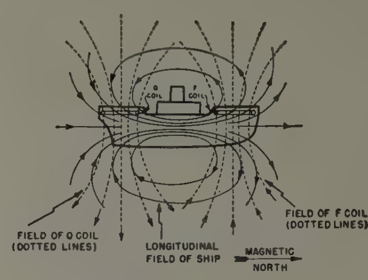



**Figure 2. Neutralization of the ship's longitudinal magnetism by the use of F and Q coils**

The ship's field resulted basically from two types of magnetism; permanent and induced. The permanent portion of the ship's field is taken on by the ship during the mechanical working of the steel, usually on one prolonged heading. This working of the steel in the presence of the earth's field causes the ship to become a permanent magnet whose magnetism changes slowly depending on subsequent magnetic history. The induced portion of the ship's field is that magnetism taken on by the ship as a result of being in the presence of the earth's field and which changes immediately as the inducing earth's field changes.

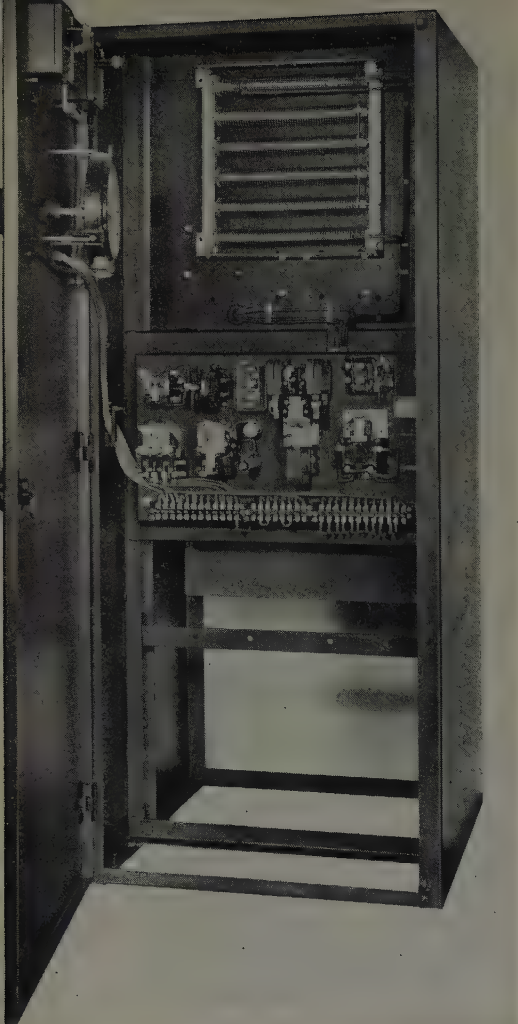
In order to counteract the permanent and induced magnetism of the ship, each of these is resolved into three mutually perpendicular components. The X-axis of these is taken as the horizontal centerline of the ship. Coils are designed to be installed within the hull that will oppose one, two, or three of the foregoing components where this component is large enough to require neutralization.

The degaussing coils are energized with direct current. The magnitudes and polarities of the currents are set by the control equipment as required for each of the different coils depending on the ship's state of permanent magnetism, the magnetic heading, the ship's location on the earth, and the function of the coil. Current setting charts are made up by occasionally sailing the ship over a line of submerged magnetic field measuring instruments. These charts indicate the proper operating currents for the coils for the various headings and for different magnetic latitudes.

Degaussing for protection of ships against magnetic mines has proved to be practical both from the standpoint of installation and operation. While it only gives partial protection since it is not feasible to install systems capable of neutralizing all of the ship's field, its value can be seen by the reduction of casualties due to magnetic mines after the use of degaussing installations was established and by the safe passage of mine sweepers through mine fields during sweeping operations.

Digest of paper 48-227, "Shipboard Degaussing Installations for Protection Against Magnetic Mines," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**N. B. Michel** is an engineer in the electrical branch, Bureau of Ships, Navy Department, Washington 25, D. C.

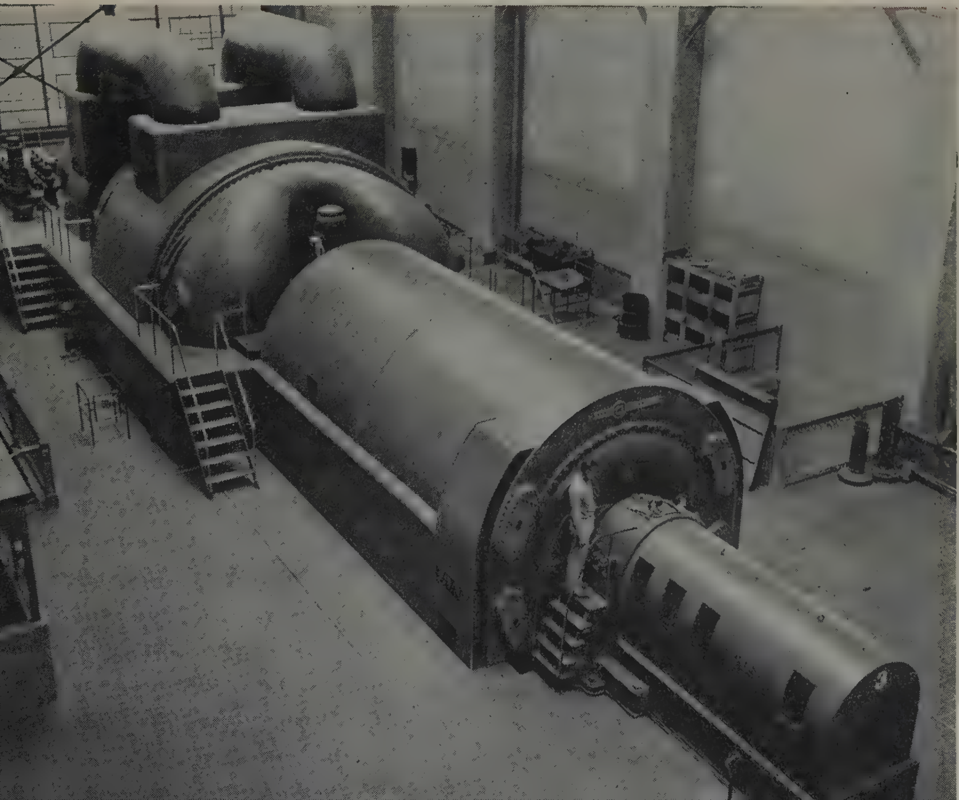


▲ The largest high-speed test generator in the world is being built and installed for a midwest electric equipment manufacturer's new tes tlaboratory by the Allis-Chalmers Company. The 22,500-kva 15-kv 3,600-rpm 3-phase generator, driven by an 800-horsepower wound rotor induction motor, will deliver 260,000 kva single-phase assymetrical line-to-line under test conditions. Backup protection is provided by a 1,500,000-kva 15-kv 2,000-ampere air-blast circuit breaker.

# 1948 ENGINEERIN

Some of the significant engine

▲ A new type Westinghouse relay provides simpler starting for synchronous motors. Using time as a "yardstick," this relay compares it to the length of a-c half-cycles induced in the unenergized field. As motor speed increases, induced voltage frequency diminishes. The relay signals the circuit to close when the time for one half-cycle equals its "yardstick."



◀ This 80,000-kw turbogenerator, put on the line late in 1948, is the third of five such units for the Port Washington plant of the Wisconsin Electric Power Company. The turbine is a tandem-compound design, using the reheat cycle. New concentrically-mounted hydrogen coolers have reduced the diameter of the generator housing and halved the total ventilating hydrogen volume. Steam conditions at throttle are 1,290 pounds per square inch (gauge) and 850 degrees Fahrenheit, with reheat at 850 degrees Fahrenheit and exhaust at 29.5 inches of mercury.

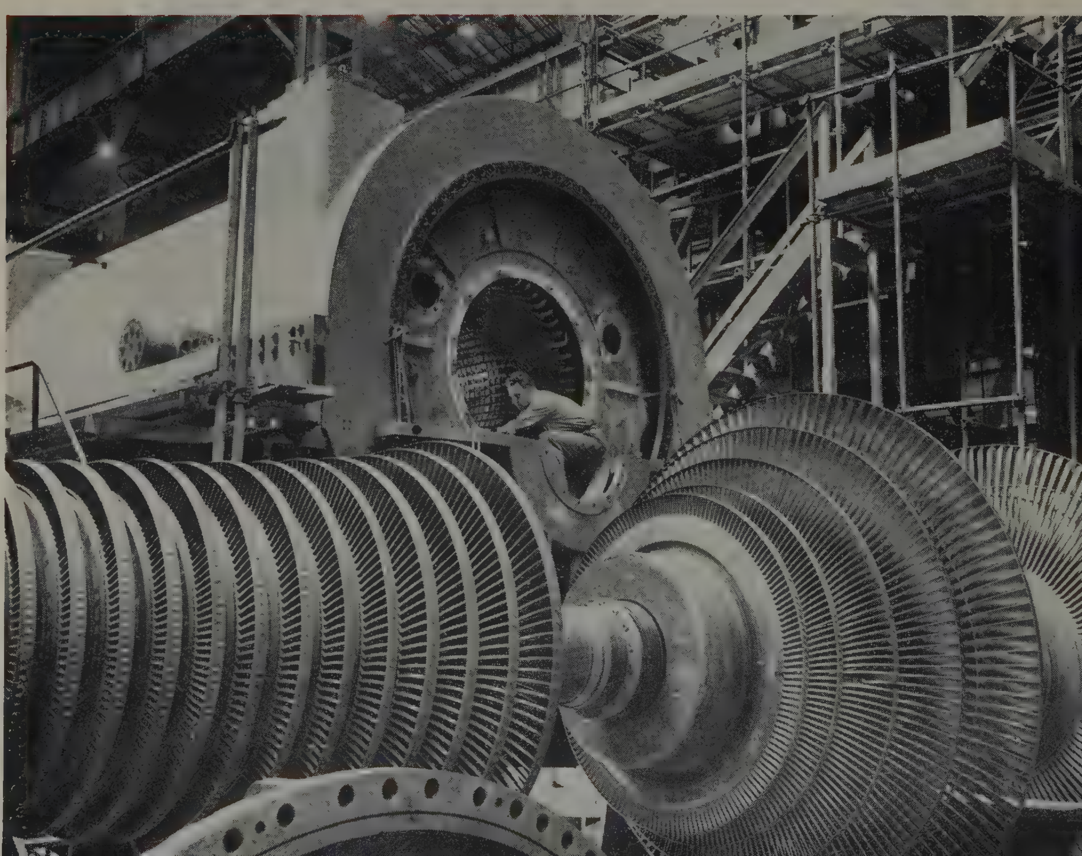
▲ This 58-ton spider for use with a 33,000-kva 225-rpm 13,800-volt Allis-Chalmers generator was shipped to a Pacific Coast hydro electric plant last year. Hydraulic turbine and generator production now exceeds prewar figures.

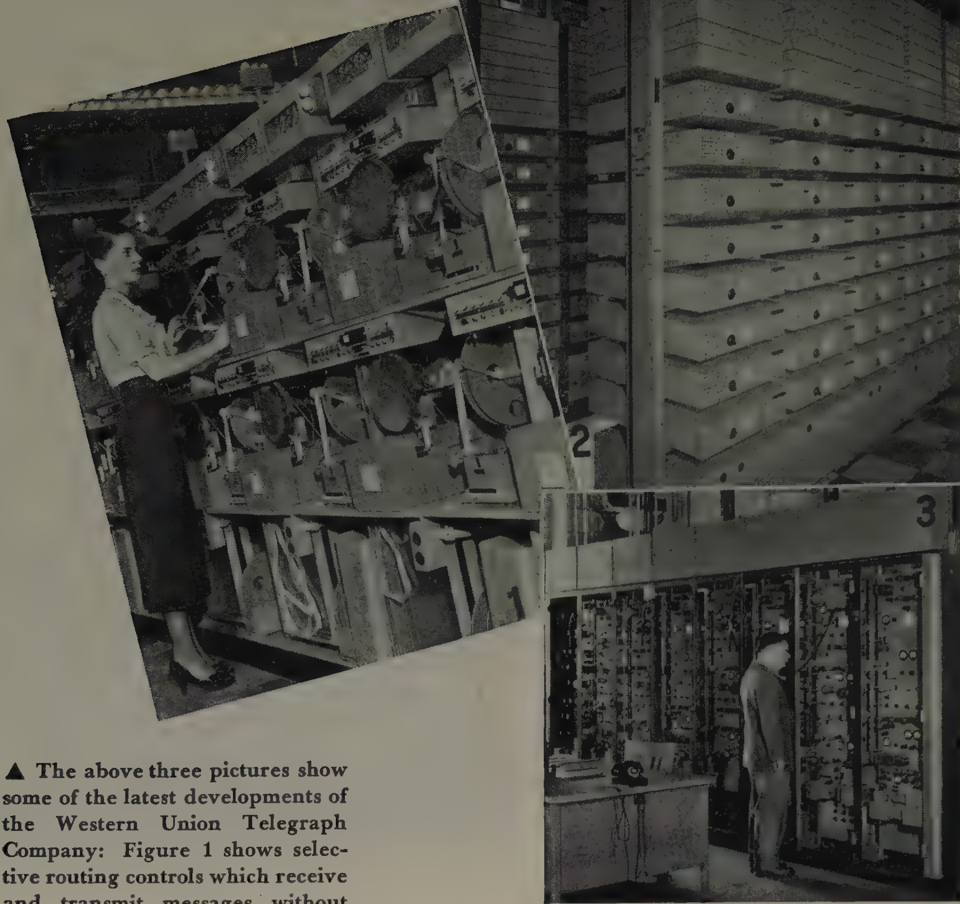
# DEVELOPMENTS

## velopments achieved last year

▲ A new type of hoist is being built by Westinghouse for the latest large cargo planes. It is rated 15,000 pound-inches at 12 rpm which means it can lift a one-ton load at almost 50 feet per minute. The cargo hoist consists of a 26-volt d-c motor (with flame arresters for explosion proofing), a magnet brake, a friction-type overspeed device, a torque-limiting clutch, a gear train, and a worm and wheel for manual operation in case of electrical failure. Because this latter is very efficient, and hence not self-locking, additional locking effect is provided in the thrust bearings of the hand crank worm.

▶ The first turbine to operate at 1,050 degrees Fahrenheit is shown in part at the Schenectady turbine works of the General Electric Company. In the foreground is shown the steam turbine rotor and the generator for the unit. Already installed for service in the new Sewaren station of New Jersey's Public Service Gas and Electric Company, this turbine is a 100,000-kw 3,600-rpm tandem compound triple - flow unit. Among its added features are hydraulic governing, pressure oiling of bearings, and interchangeability of parts.






▲ The above three pictures show some of the latest developments of the Western Union Telegraph Company: Figure 1 shows selective routing controls which receive and transmit messages without delay, and also avoid manual retransmission; Figure 2 shows modern space-saving carrier telegraph channel terminals, operated on wire lines or microwave radio; the New York City terminal of Western Union's microwave radio relay circuits is shown in Figure 3. There are circuits to Philadelphia, Pa., Washington, D. C., and Pittsburgh, Pa. Each unit has a capacity of 640 2-way voice frequency telegraph channels.

▲ The first
sideband carrie
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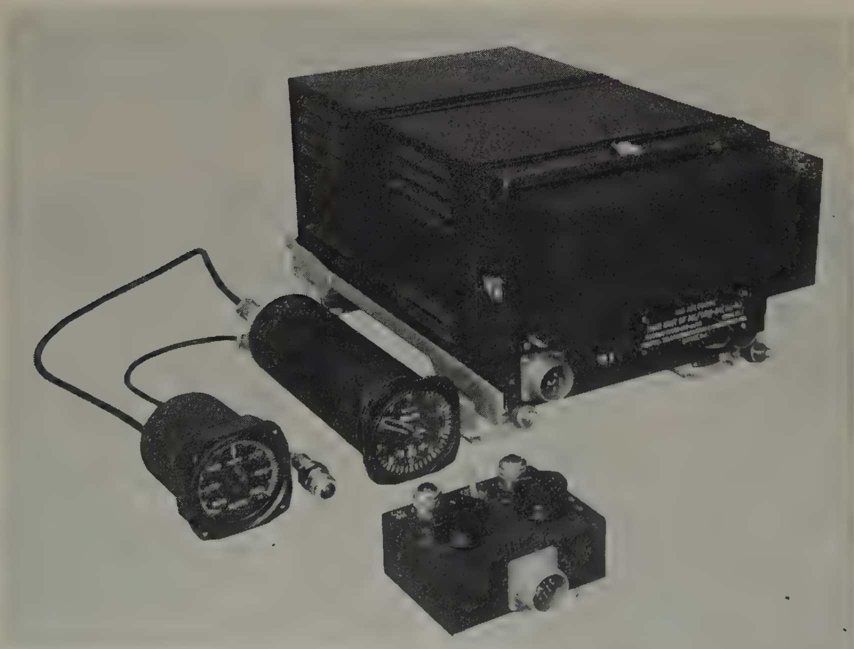
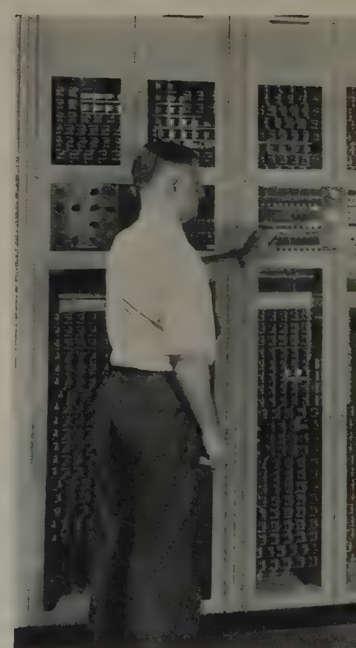
house as an
congested
communication



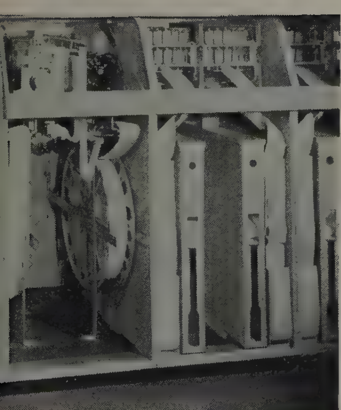
▲ Distance measuring equipment, like that pictured, was the significant development in aerial navigation for 1948. This newly established distance-bearing system operates in the 1,000-megacycle region and consists of an air-borne interrogator working in conjunction with ground transpondors in a 2-way pulsed system which provides the pilot with accurate and continuous meter indication of the aircraft's distance and speed in reference to ground stations along the air route.



▲ This is part of the new a
matic message counting equipm
designed by Bell Telephone La
ratories, and now being insta
in various parts of the Bell Syst
By means of an "electric bra
billing information is recorded

ns have been installed. In this system, e carrier frequency is suppressed, with ly one sideband frequency being transmitted, and it only when signals are being nveyed. With channels narrower, interference is proportionately less.

▲ The Federal Telecommunication Laboratories, research unit of the International Telephone and Telegraph Corporation, has completed this specially designed 300-foot microwave research tower at Nutley, N. J., to provide laboratory facilities for microwave and television research, such as line-of-sight transmission and microwave technique.



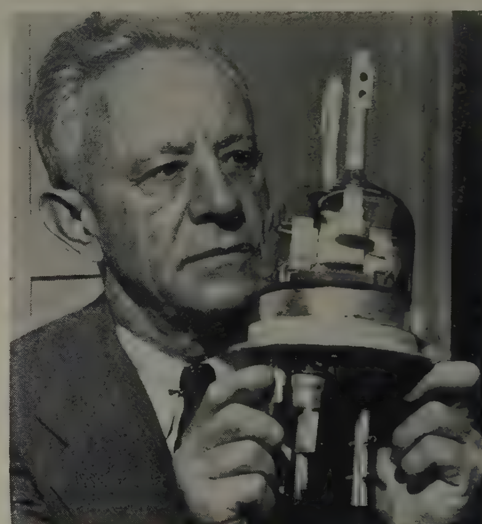
a coded paper tape and later assembled, sorted, summarized, and printed by machines in the accounting center. As many as 25,000 calls can be recorded on one tape.

▶ A new type of metal lens for focussing radio waves in radio-relay systems is under development at Bell Telephone Laboratories. Theoretically capable of handling from 50 to 100 television channels, or tens of thousands of simultaneous telephone messages, this lens will be used in the proposed link between New York and Chicago.

▲ One of the outstanding developments of the year was Bell Telephone Laboratories' transistor. This enlarged view shows the relative size of the transistor as compared with a paper clip. Serving as an amplifier or an oscillator, it performs all the functions of a vacuum tube without a vacuum, glass envelope, grid, plate, or cathode (for details see EE, Aug '48, page 740).

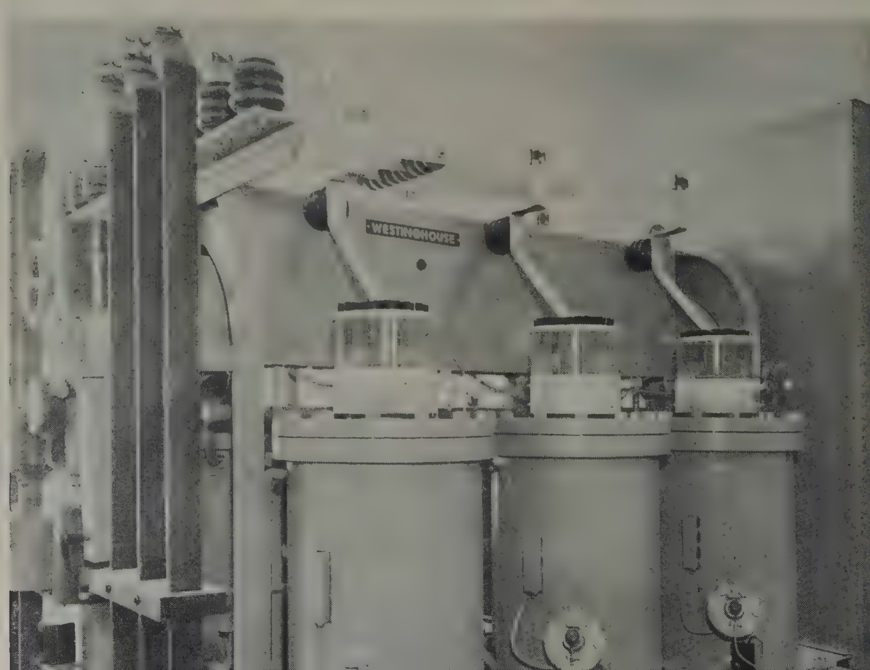
▲ Geiger counters such as these developed by Westinghouse Electric Corporation found increasing use in nuclear research work last year. One of these is a cylinder of chrome steel, one inch in diameter and six inches long, through which a heavy wire extends from an insulator at one end to almost the far end. The wire is covered by a wafer of mica one half a thousandth of an inch thick. The tube is filled with a precisely controlled mixture of neon, argon, and an exact trace of chlorine to hasten deionization.

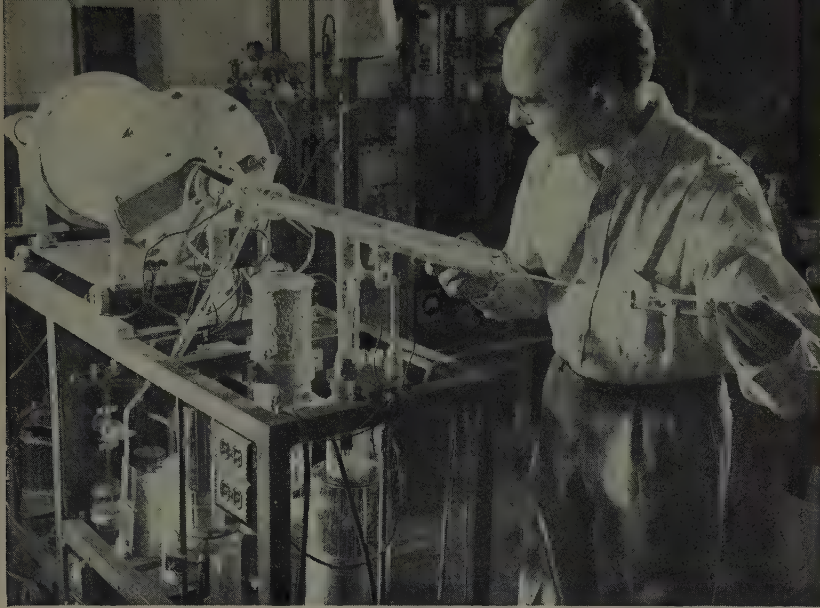
▶ An example of electronic advance is this newly developed RCA 8D21 5-kw power tube, the first tube of its kind for the transmission of both television sight and sound. The tube provides watercooling for every active electrode surface.



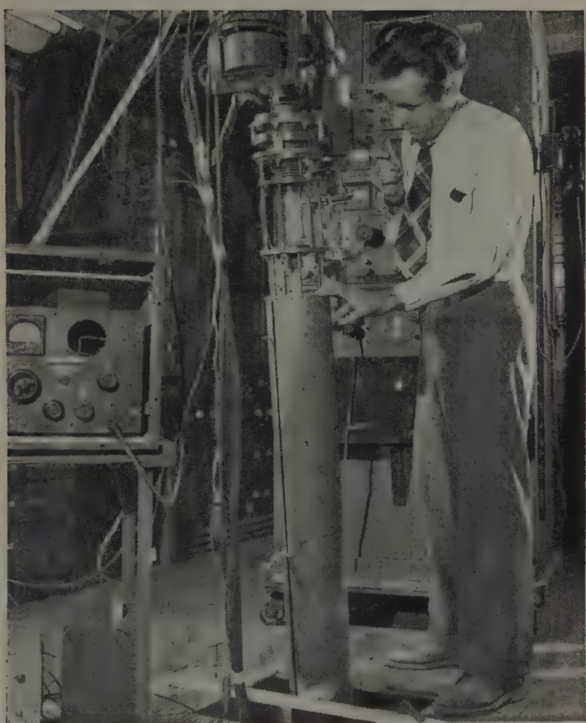
▼ Control console of Radio Corporation of America's new large screen television projector which can produce pictures six by eight feet through a system of reflective optics placed before any standard television source.

▼ Voltage ratings of continuously-pumped-type ignitrons were increased last year. A single 3,000-kw 3,000-volt rectifier of this type developed by Westinghouse has been supplying power to mining locomotives in Utah for nearly a year. With special grid and extra heavy construction, it has been able to operate at high voltages and under sudden, large load swings.

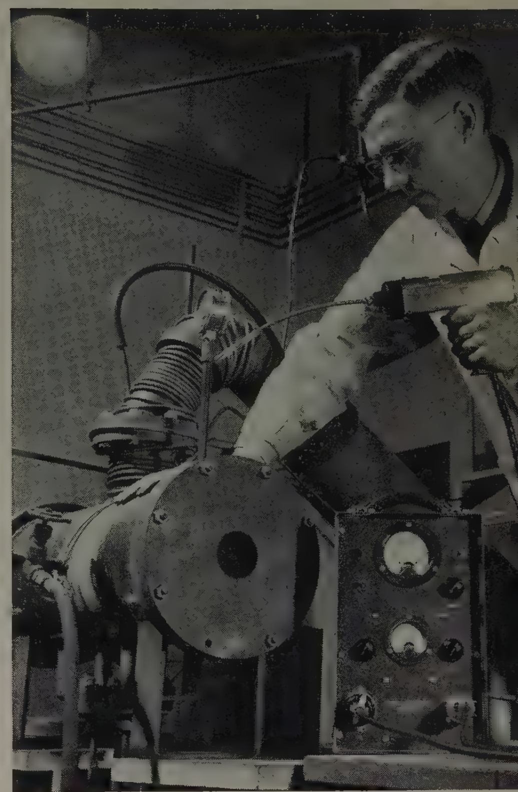




◀ New type "furnace" designed in the Westinghouse research laboratories for preparing single crystals of metal to facilitate the study of their physical characteristics. To determine why and how metals form different structures under different conditions, a single crystal is made and then studied by electron and X-ray diffraction tests under all temperature conditions.

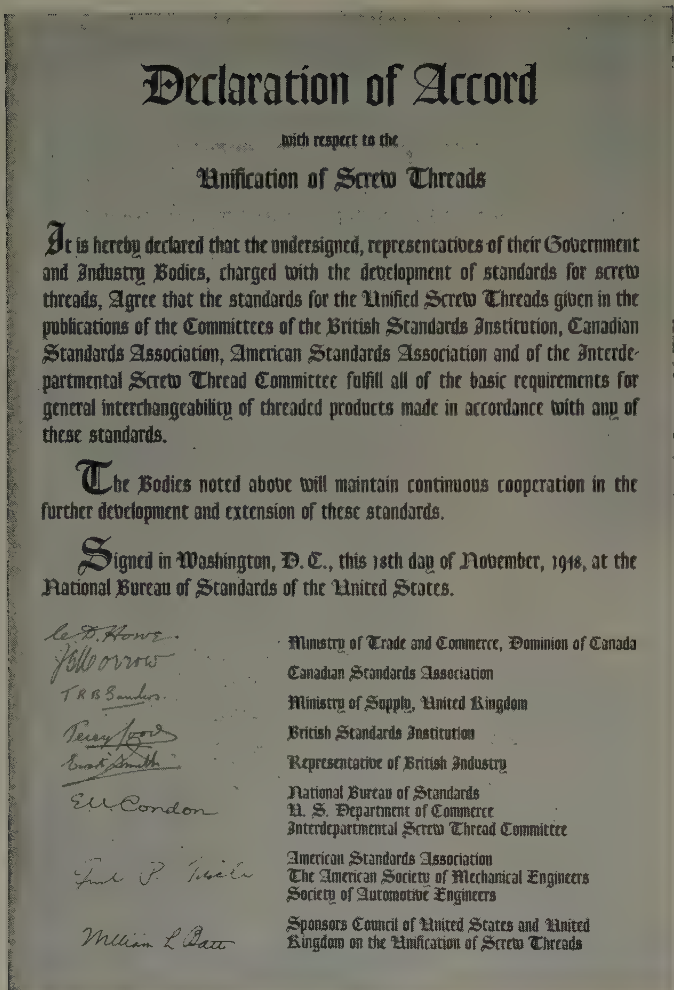


◀ Highly accurate measurement of the threshold voltages of elements is being made by Westinghouse research engineers by means of this measuring device mounted in the ion stream of the Van de Graaf generator. Consisting of an outer 70-megacycle resonant tube and an inner tube with ends so arranged that the two tubes form sets of parallel plates, the device is connected to a receiver and meters. Scientists can watch the first release of neutrons in the nuclear reaction, note the meter reading, and calculate the threshold voltages.



▲ A new leak detector, capable of detecting a leak of freon as small as one ounce in a century, has been developed by the General Electric Company. It works on the principle that ion emission from the hot filament of a sensitive element is increased by presence of a halogen gas.

▶ The first gas turbine electric locomotive to be built and operated in the United States, an American Locomotive Company–General Electric Company 1,500-horsepower unit, began track tests last November. To be used on the Union Pacific Railroad, the locomotive is of single-cab construction with an operating station in each end. Carrying enough fuel for 12 hours of operation at 4,500 horsepower, it develops 53 horsepower per foot of length and is geared for 79 miles per hour.



# Declaration of Accord

with respect to the

## Unification of Screw Threads

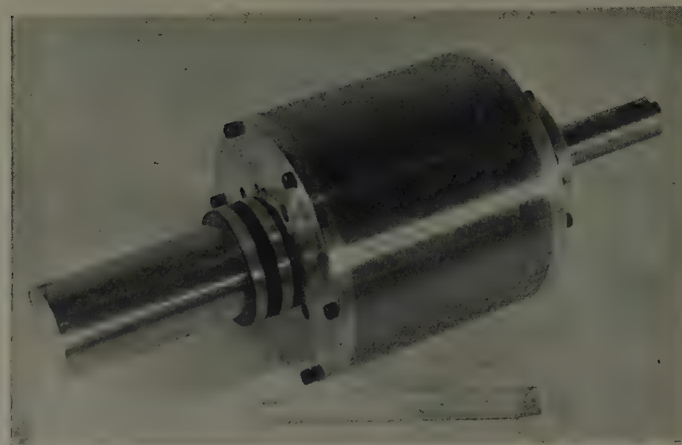
It is hereby declared that the undersigned, representatives of their Government and Industry Bodies, charged with the development of standards for screw threads, Agree that the standards for the Unified Screw Threads given in the publications of the Committees of the British Standards Institution, Canadian Standards Association, American Standards Association and of the Interdepartmental Screw Thread Committee fulfill all of the basic requirements for general interchangeability of threaded products made in accordance with any of these standards.

The Bodies noted above will maintain continuous cooperation in the further development and extension of these standards.

Signed in Washington, D. C., this 18th day of November, 1948, at the National Bureau of Standards of the United States.

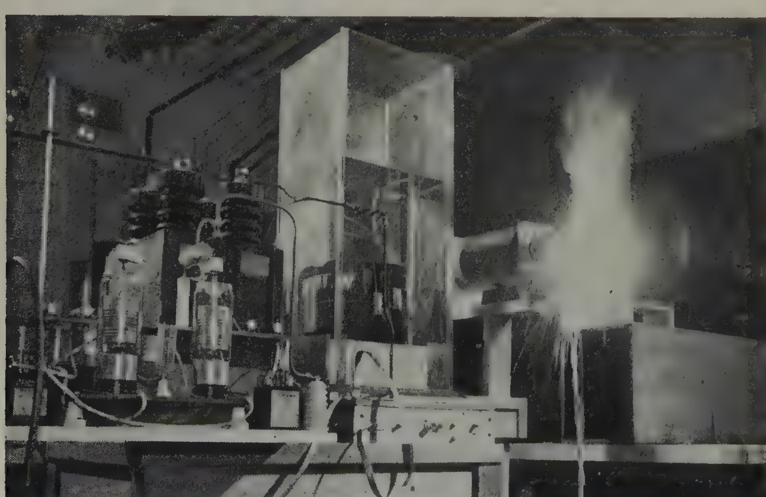
| | |
|---|---|
| C. D. Howe | Ministry of Trade and Commerce, Dominion of Canada |
| J. G. Morrow | Canadian Standards Association |
| T R B Sanders | Ministry of Supply, United Kingdom |
| Percy Good | British Standards Institution |
| Ernest Smith | Representative of British Industry |
| E U Condon | National Bureau of Standards<br>U. S. Department of Commerce<br>Interdepartmental Screw Thread Committee |
| Fred P. Tisch | American Standards Association<br>The American Society of Mechanical Engineers<br>Society of Automotive Engineers |
| William L Batt | Sponsors Council of United States and United Kingdom on the Unification of Screw Threads |

▲ An outstanding engineering development of 1948 was screw thread standardization. This is a copy of the historic document signed by representatives of the United States, Canada, and Great Britain which standardizes the systems of screw threads for all three nations. This is the culmination of 30 years of effort to unify their thread systems, and represents a major advance in international standardization. (See EE, Dec '48, page 1221.)



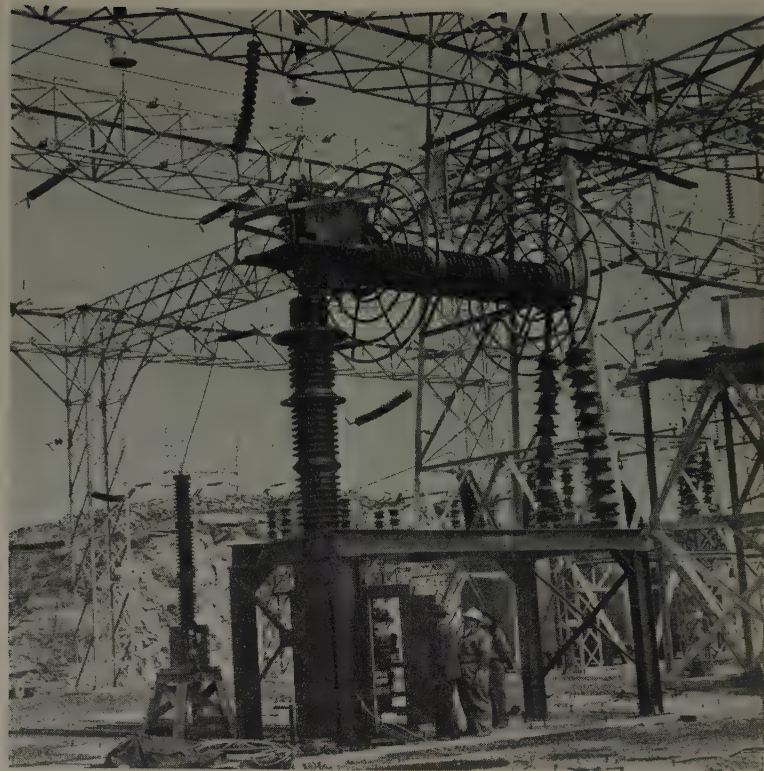
▲ An interesting development of 1948 was a new type of electromagnetic clutch developed at the National Bureau of Standards, known as the magnetic fluid clutch. This device consists of two plates separated by a magnetic fluid such as iron powder mixed with oil. Variation in the strength of an applied magnetic field determines the degree of coupling between the plates. Features of the new clutch include ease of control, high efficiency, smooth operation, rapid reversal, long life, and simplicity of construction. Shown here is an electromagnetic clutch of the type suited to use in automobiles and machinery. This unit is 6 inches in diameter and $6^1/_2$ inches long, and can transmit 40 horsepower at 300 rpm. (See EE, May '48, page 444; Dec '48, page 1177 for details.)

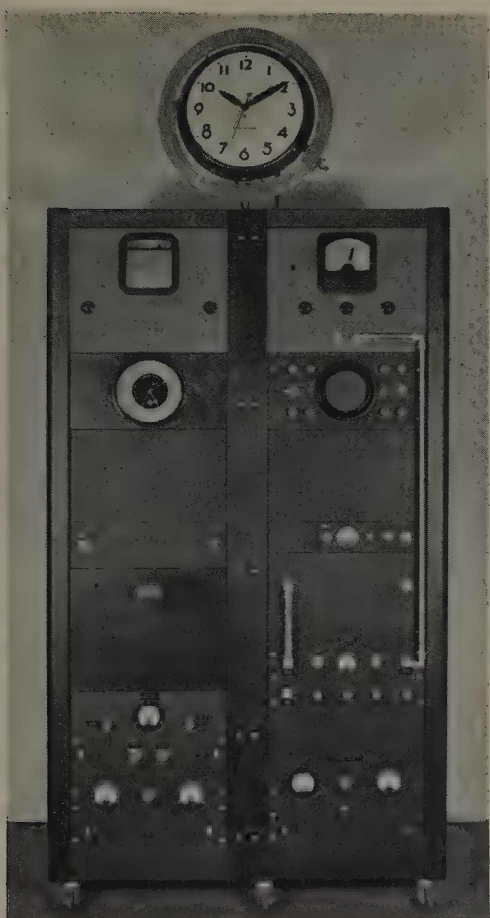
▼ In the field of special high-speed photography, a technique of making super speed X-ray movies was developed in the Westinghouse lamp research laboratories. The technique involves the use of X-ray exposures 10 millionths of a second long and a shutterless camera shooting 100 frames per second. X-ray movies are being made here of the chemical reaction occurring when iron oxide and aluminum are ignited.



▲ Magnetic suspension of the moving element is the outstanding feature of a single-phase watt-hour meter introduced by the General Electric Company during 1948. A cunico magnet is attached to the frame; another is an integral part of the disk-and-shaft assembly. Interaction of the two magnetic fields supports the moving systems in a state of equilibrium. (For full details, see EE, July '48, pages 627-9.)

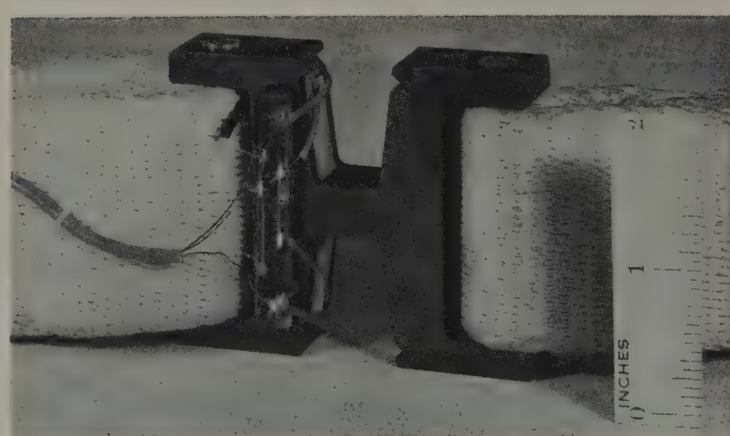
▶ Early last year an unprecedented series of switchgear tests were made. The maximum short-circuit capacity of the Grand Coulee power plant and the Northwest Power Pool was interrupted with ease in less than three cycles and the circuit reclosed in less than ten cycles by this high-speed impulse-type General Electric circuit breaker. This unit is similar to the one developed in 1947 for the 500-kv experimental Tidd project of the American Gas and Electric Company.





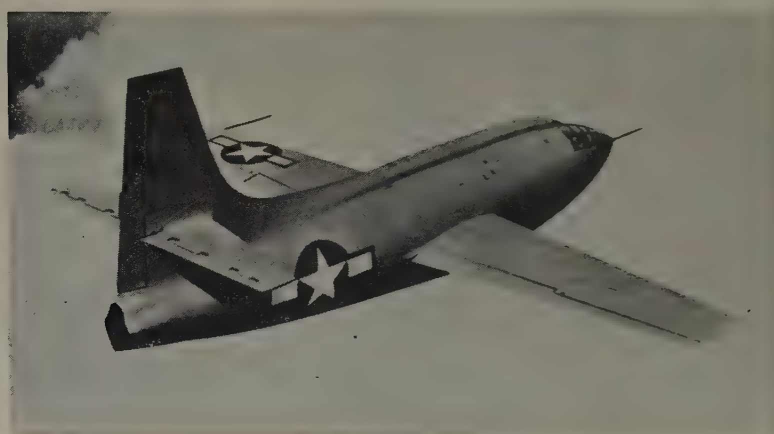
◀ This is the National Bureau of Standards atomic clock in which a quartz-crystal oscillator and frequency multiplier chain are locked to an absorption line of ammonia gas at a frequency of 23,870.1 megacycles. The crystal drives a clock through frequency dividers giving a new standard of physical or atomic time. A potential accuracy of one part in 100 million is indicated, and because the absorption-frequency line is invariant with age, the time and frequency accuracy is permanent.

▶ A gauge assembly capable of measuring and telemetering opening shock strains up to 5,000 pounds is illustrated. Developed by the National Bureau of Standards for the United States Naval Bureau of Aeronautics, it will serve as links in various parts of the harness and webbing of parachutes. In test jumps, the outputs of five such gauges are impressed upon a radio signal and transmitted to a ground station for study.



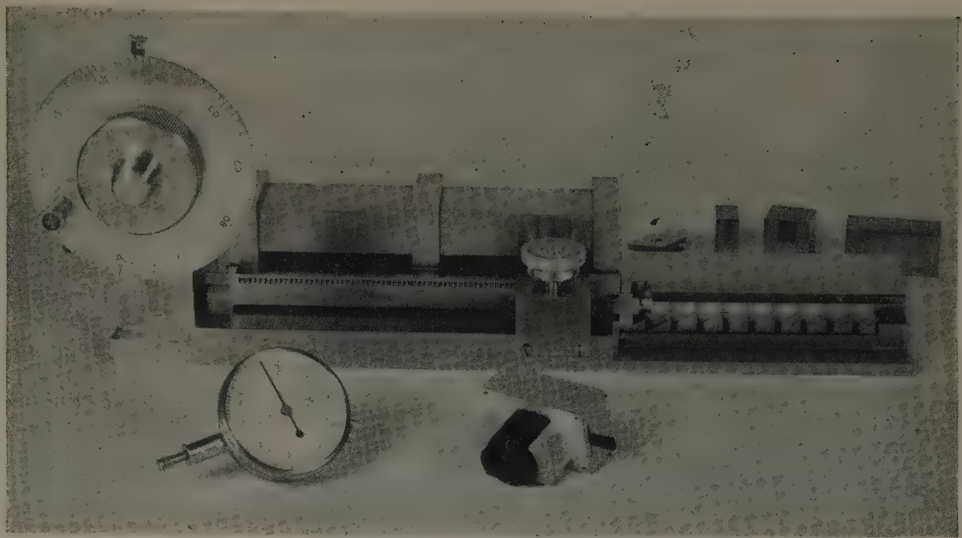

◀ The latest United States Air Force standard production model jet fighter, the North American F-86, which set the world's speed record of 670.981 miles per hour in September 1948. With wings swept back at a 35 degree angle, it has the most powerful jet engine in production, the General Electric TG-190 which develops over 5,000 pounds thrust. The plane incorporates an ejection seat, refrigeration system for high-speed flight, and radio and radar navigational aids.

▶ The Bell X-1, supersonic research plane, was reported officially to have flown beyond the speed of sound in June 1948. First flight beyond the supersonic barrier was made October 14, 1947. This rocket-propelled plane was tested by the United States Air Force at Muroc Lake, Calif.



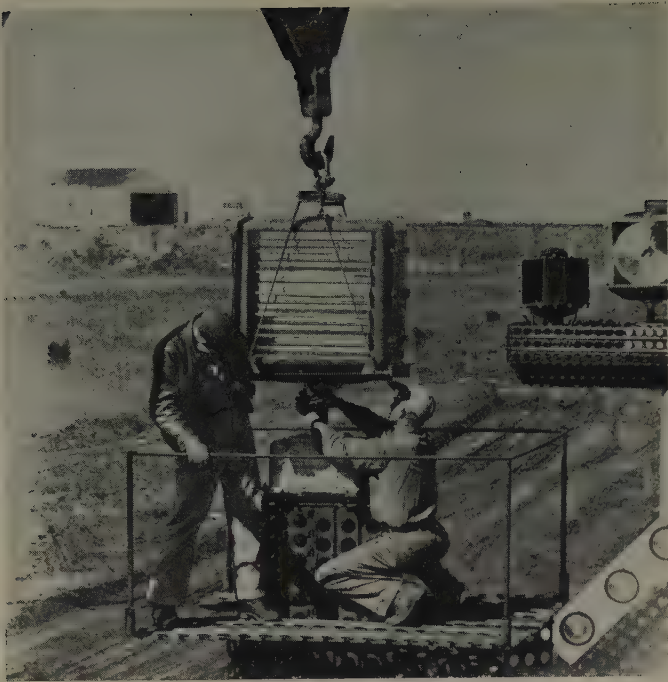
◀ The world's largest boom conveyor driven by a General Electric 300-kw induction motor, has been installed aboard the freighter S.S. Crispin Oglebay. This self-loading vessel recently was converted by American Shipbuilding Company for Great Lakes service, and is owned by the Columbia Transportation Company.

▶ A new primary standard of attenuation, developed at the National Bureau of Standards, controls power levels and precisely measures changes of one part in 5,000. Operation is based on the principle of choking out all signals above the cut-off wave length of the waveguide which is accurately formed from copper by electro-deposition. Thus, all waves which are too large to propagate through this cavity are cut off. The attenuator has an over-all operating range of 100 decibels or power level changes of ten billion to one, and can make accurate measurements over the entire microwave region by the hetrodyne method.



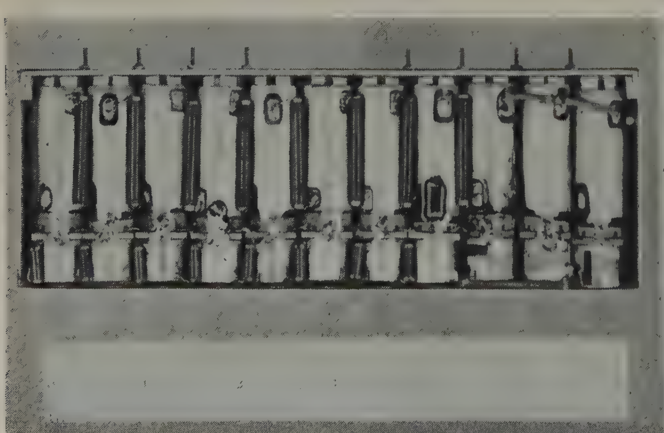
◀ Precision voltage measuring equipment, developed at the National Bureau of Standards, has provided a primary standard, for use at high frequencies. Utilizing a reference standard cell, this apparatus produces sinusoidal radio-frequency voltages at frequencies up to several hundred megacycles for standardizing voltmeters, signal generators, and similar instruments to a high degree of accuracy.

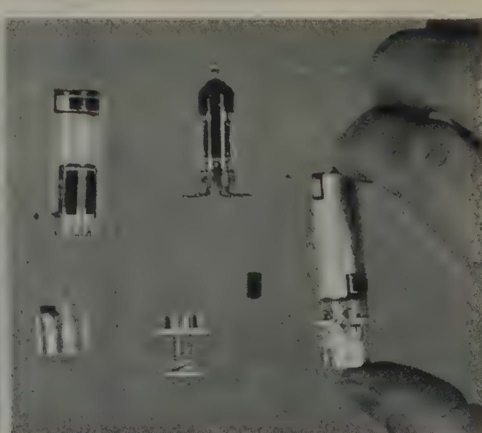
▶ A new dry electrostatic means for printing has been developed by the Battelle Memorial Institute, and now is being licensed by the Haloid Corporation of Rochester, N. Y. Using the principles of photoconductivity and the electrical attraction of dissimilar materials in contact, the device uses a special dry powder attracted to an electrically charged image on paper and then set by the application of heat. The picture shows the inked paper emerging from the powder receptacle, just prior to being set. (For full details, see page 46 of this issue.)



◀ Workmen are shown guiding a big Westinghouse neon "blaze" unit onto its mounting in the approach area at the Landing Aids Experiment Station, Arcata, Calif., operated by the Transocean Air Lines for the United States Air Force and Navy and for civilian sponsors. Thirty-four units of this type and 35 krypton flash units, the world's brightest lights, compromise the Westinghouse all-weather approach system now being tested and evaluated. Mounted alternately in a line about 3,500 feet long, the 69 lights may be controlled by a master synchronizer to produce lightning-like flashes to guide fog-bound pilots to the main runway. These "lightning flashes" travel toward the runway from a point near the "inner radio marker" at the outer end of the approach area, to which the pilot is guided by the instrument landing system (ILS) beam.


▲▼ Miniaturization of electronic equipment showed great progress in 1948. Using newly developed techniques, the National Bureau of Standards has reduced the volume to one-sixth present size on certain vital electronic gear for the Navy Bureau of Aeronautics. Shown above is a model of a 60-megacycle wide-band high-gain, intermediate-frequency amplifier made with subminiature tubes and miniature parts. Below is a similar intermediate frequency amplifier constructed of printed electronic assemblies as well as parts from a single printed amplifier stage. Special insulating materials were used to combat high temperatures produced by the reduction in size.





# A New Distance Ground Relay

S. L. GOLDSBOROUGH
MEMBER AIEE

DISTANCE-TYPE relays have been used successfully for many years to protect against phase faults on transmission lines. However, distance relays to protect against ground faults in the same satisfactory manner as for phase faults have not been generally available. The chief reason for the delay in producing these is that a ground fault is much more involved than a phase-to-phase fault so that the simple use of line-to-ground voltage and line current does not produce the right answer. The error is caused by the fact that the zero-sequence-line impedance is not equal to the positive sequence impedance, therefore distance response is varied by changes in the distribution of the positive, negative, and zero sequence currents caused by changes in system connections outside the protected line section.

To overcome these errors either current or voltage compensation is required. The new relay utilizes the voltage compensation method wherein the positive and negative sequence voltage drops from the relay location to the balance point are subtracted from the line-to-ground voltage, thus leaving only the zero sequence voltage drop $I_0Z_0$. Combining this voltage with the zero sequence current, a response to $Z_0$, the impedance from the relay to the fault, can be obtained. With this arrangement a reactance element can be utilized without difficulty since there can be no response to load ohms. Since there is only one operating current ($I_0$), one relay to operate on single-phase-to-ground faults on any one of the three phases can be used with a phase selector relay to switch the voltage circuit to the faulted phase-to-ground voltage. The phase selector used for this purpose is the negative sequence versus zero-sequence-current-phase selector which has proved satisfactory in connection with single-pole tripping and reclosing.

The new ground relay equipment consists of a phase selector relay, a 3-zone reactance relay, and an auxiliary unit. Figure 1 shows the a-c schematic connections of the three relay units restricted to one distance element. The zero sequence current first is removed from the center top leads by the three auxiliary 15/5 current transformers, leaving only the positive and negative sequence currents to pass first through the 3-phase negative sequence network and then through the three compensators. These compensators are similar to line drop compensators, producing secondary voltages proportional to, and the same angle as, the corresponding voltage drops on the high-voltage line. These voltages are subtracted from the line-to-ground voltage, leaving only the zero sequence voltage drop $I_0Z_0$ to be applied to the beam-type relay element. In order to obtain a reactance characteristic from a beam-type element,

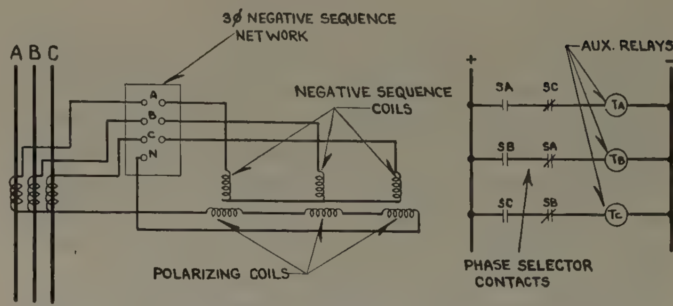



**Figure 1. Schematic connections of phase selector elements**

it is necessary to balance the vector sum of the current and voltage on the operating or contact end of the beam against a voltage restraint on the back end of the beam. Also, the voltage ampere turns on the operating end must be shifted 90 degrees leading or the current lagged 90 degrees with respect to the voltage. Furthermore, the mechanical pull of the operating end voltage without current must equal the restraint voltage pull.

The induced voltage in the secondary of the mixing transformer lags the primary current by 90 degrees and this current-derived voltage and the compensated line-to-ground voltage are directly combined in the single operating coil on the reactance element. It is permissible to mix the current and voltage circuits in this fashion since the current from the current circuit is stepped down to the order of magnitude of the current produced by the voltage circuit and the secondary impedances of the mixing transformer, the compensators and the potential transformers are relatively negligible.

The zero sequence current is mixed vectorially with the zero sequence voltage and applied to the operating end of the beam and the voltage alone is applied to the restraint end of the beam. This combination causes the beam to respond in accordance with the reactance of the transmission line. The proper compensated line-to-ground voltage is applied to the element through the action of the auxiliary phase selector contacts.

This ground relay equipment, successful in laboratory and field test and utilizing a negative-zero sequence phase selector, is intended primarily for application on essentially solidly grounded systems. On systems grounded through appreciable values of impedance, a voltage-type selector can be used to advantage. Impedance grounded systems generally produce a considerable neutral shift, thus, on single-phase-to-ground faults, the faulted phase-to-neutral voltage drops to a relatively low value while the other two voltages rise considerably above the normal line to neutral value. A voltage phase selector utilizing one of the unfaulted line-to-ground voltages as an operating voltage balanced against the faulted voltage as a restraint voltage provides a very positive means of selecting the faulted phase.

Digest of paper **48-260,** "A New Distance Ground Relay," recommended by the AIEE relay committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**S. L. Goldsborough** is with the Westinghouse Electric Corporation, Newark, N. J.

# Precision Electrothermic Voltmeter

F. L. HERMACH
ASSOCIATE AIEE

AN ELECTROTHERMIC VOLTMETER of the thermocouple type, with an adjustable resistor in series with an insulated-heater, evacuated thermoelement has been developed at the National Bureau of Standards primarily for standardizing voltmeters over a wide voltage range at audio frequencies. In conjunction with a suitable d-c potentiometer, it can be used for measuring alternating voltages from 0.4 to 400 volts at frequencies from 20 to 20,000 cycles per second, with an accuracy of 0.01 per cent. The voltmeter was intended specifically for use solely as a transfer instrument. Such instruments are designed to have ideally the same response on alternating current as on direct current, so that when calibrated with direct current they become standards which, in effect, transfer the units of measurement (which are maintained by d-c standards) to alternating current. By making sufficiently frequent calibrations, only the transfer performance or frequency influence becomes significant, and instruments intended for such use may be designed and constructed for the best possible transfer performance and for high sensitivity, at the expense of other characteristics.

For this transfer instrument, an insulated-heater thermoelement, which inherently measures rms current over a wide frequency range, was adapted for voltage measurements by the use of an adjustable series resistor.

A commercially available but slightly modified, shielded, audio-frequency decade resistance box was found to be entirely suitable over the full frequency and voltage ranges. The series inductance, skin effect, and direct capacitance of all decades were negligible (less than 0.01 per cent) in this range, and the shunt capacitance to the shield for the higher decades was relatively innocuous for the 3-terminal connection as shown in Figure 1.

To obtain adequate sensitivity, an elementary form of deflection potentiometer of the Lindeck type is used in the thermocouple circuit. For voltage measurement, as in an a-c test of a voltmeter, the series resistor is adjusted so that the current through the thermoelement is within a few per cent of a selected reference level, the Lindeck element is set to a voltage very nearly equal to the emf of the thermoelement at this level, and the indication of a reflecting galvanometer, which responds to the unbalanced voltage in the potentiometer circuit, is observed. The standard voltmeter is then connected to direct current, and the voltage for the same indication at the same settings is measured with a d-c potentiometer. In a transfer test of a voltmeter, the small differences in the applied voltages at the two frequencies during a determination are measured by observing the successive indications of the galvanometer with all settings unchanged. The scale of the galvanometer covers about three per cent of the total indications of the thermoelement and is readily calibrated directly in per cent differences in applied voltage. It may be read easily to 0.005 per cent.

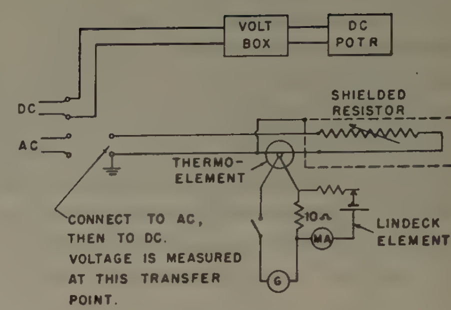



**Figure 1. Schematic diagram of volt-meter circuit**

The voltmeter was designed and constructed to be as free as possible of sources of a-c–d-c differences, and the magnitudes of the differences resulting from all known sources at least were computed roughly. This is the most significant part of the development of an instrument of this type. To guard against the possibility of appreciable errors from unsuspected causes, the completed voltmeter was tested by comparing its transfer performance with that of other types of instruments. At power-line frequencies (30 and 60 cycles per second) the comparison was made at several voltages with a suppressed-zero electrodynamic voltmeter regularly used for testing voltmeters at these frequencies. The observed differences were less than 0.005 per cent. Comparisons at several frequencies between 30 and 20,000 cycles per second were made with two portable high-grade electrostatic voltmeters. The comparisons were made at the rated voltage of each instrument, 150 and 300 volts, and the observed differences were 0.01 per cent or less, the limit of measurement. The combination of comparisons verified the absence of significant transfer errors in the voltmeter.

The instrument is used at the bureau primarily for testing other voltmeters which respond to direct and alternating currents, and consist of measurements of their a-c–d-c differences at one or more frequencies in their range. Rapid and accurate tests also are made with 60 cycles per second as the reference frequency, for voltmeters which do not respond to direct current. These determine the frequency influence on the instrument under test. This characteristic is relatively permanent for a given instrument, so that future tests need be made only at a reference frequency. Direct a-c tests also are made for instruments which respond only to a narrow range of frequency, but the results are therefore less permanent and of less value than those of transfer tests.

Digest of paper 48-218, "A Precision Electrothermic Voltmeter for Measurements Between 20 and 20,000 Cycles Per Second," recommended by the AIEE instruments and measurements committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**F. L. Hermach** is with the electrical instruments section, division of electricity and optics, National Bureau of Standards, Washington, D. C.

# Two Electrical Essays

## The Black Box

AN ELECTRICAL ENGINEER is asked to investigate a setup as shown in Figure 1. A d-c generator with a terminal voltage of 100 volts furnishes current to a series combination of resistance of 5 ohms and a black box with two terminals. The current in the circuit, as indicated by the meter $M_1$, is 10 amperes, and the voltages across the two series elements are each 50 volts, as indicated by the meters $M_2$ and $M_3$. The 5-ohm resistor is rated 500 watts, but it runs a good deal hotter than the manufacturer claims it should with rated wattage; the black box, on the other hand, runs completely cool. The engineer explains this latter phenomenon by proclaiming that

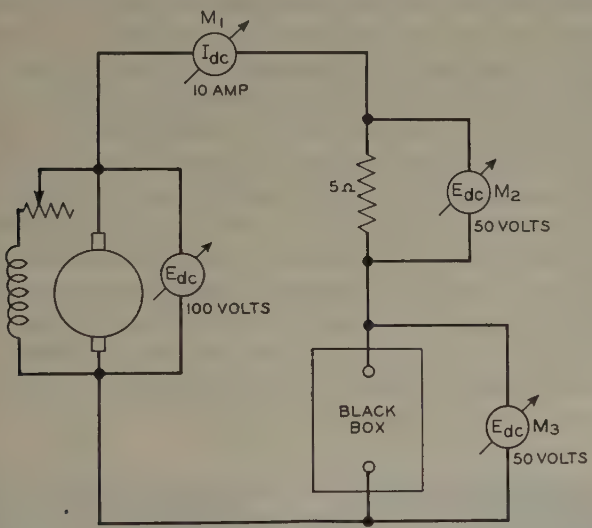



**Figure 1**

electric energy is not converted into heat, but into some other form of energy in the black box (for instance it may contain batteries being charged). Just to be sure of himself he connects a wattmeter in the circuit. The current coil of the wattmeter is placed in series with the ammeter, and the voltage coil is connected successively across the generator terminals, the 5-ohm resistor, and the black box. The readings of the wattmeter in the three places are respectively as follows: 1,000 watts, 1,000 watts, and zero watts for the black box!

Do you think that any moment now you are going to wake up from a bad dream or do you feel that there actually could be something in the black box giving such an astonishing result?

WALTHER RICHTER (F '42)
(Allis-Chalmers Manufacturing Company, Milwaukee, Wis.)

## Space Charge Theory Exploded

It is well-known that a hollow uniform spherical shell of electric charge produces zero electric field everywhere within it. At points outside the shell, the field is the same as if all the charge were concentrated at the center of the sphere.

Consider now a small charge of small geometrical dimensions, and of the same polarity as the spherical charge distribution, and consider the force exerted upon this small charge by the spherical charge as the small charge passes from the center, out along a radius. At the center, of course there is no force. As the small charge moves outward, there continues to be zero force until the small charge reaches the shell. After the small charge passes through the shell, the small charge is driven by a force, but this force urges the small charge outwardly, away from the center.

At no point can the spherical shell be said to be "repelling" the small charge back toward the center!

If the charge distribution is a thick spherical shell, with a radial distribution of density, the preceding remarks continue to hold. At any radius, the force on the small charge due to the charge distribution at larger radius is zero, and that due to the charge distribution at smaller radius, drives the small charge outwardly. The spherical charge distribution then, never "repels" the small charge back towards the center, but rather, "repels" it away from the center.

An exactly similar situation exists for a long cylindrical distribution of charge. Such a charge distribution never will "repel" a small like-polarity charge back toward the center, but rather will "repel" it away from the center.

This discussion has a bearing on the explanation which commonly is given of the space-charge saturation characteristic of a thermionic tube.

Consider a tube having a single thermionic filament, and a surrounding cylindrical anode. With a given voltage between anode and filament, consider the course of the electron current to the anode as the filament temperature is raised from a low to a high value. At low filament temperatures, all the electrons emitted by the filament reach the anode, and the anode current increases as the filament temperature and electron emission increases. A point is reached, however, where further increases in filament temperature and electron emission do not increase the anode current.

The explanation generally given is that the electrons in transit, constitute a space charge, which when sufficiently intense will "repel" back to the filament all additional emitted electrons.

From the foregoing discussion it is clear that this explanation is not tenable. The cylindrical space charge will not "repel" emitted electrons back to the filament, but rather will "repel" them away from the filament.

Of the books on the library shelves in the Westinghouse Research Laboratory which deal with this subject, about three-quarters give the erroneous explanation discussed in the foregoing.

J. SLEPIAN (F '27)
(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

# Characteristics of the Arc in "Heliarc" Welding

H. T. HERBST

**Two distinctly different properties of an electric arc in an atmosphere of inert gas—a cleaning action of the arc when d-c reverse polarity is used on oxide-forming metals, and the resistance to current flow which is considerably higher when the electrode is positive—are described showing their effect on the application of the "Heliarc" welding process.**

"HELIARC" WELDING is distinctly different from other methods of arc welding in that the arc is drawn between the workpiece and a virtually nonconsumable tungsten electrode while the electrode, the arc, and the weld metal are protected by a sheath of inert gas. The use of an inert gas as a shielding medium gives this process an outstanding advantage since it makes it unnecessary to use flux when welding most of the common metals.

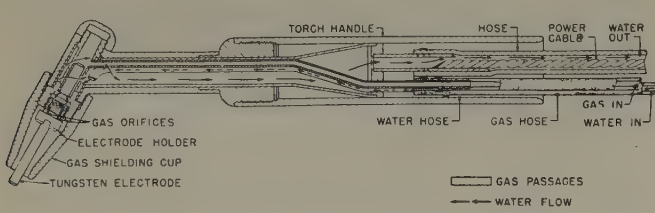



**Figure 1. Cutaway view of "Heliarc" torch**

The electric arc in an atmosphere of inert gas has two particular properties that differ decidedly from those encountered in the metal arc-welding process, which uses coated electrodes and which transfers metal across the arc.

The first of these properties is a cleaning action of the arc when d-c reverse polarity is used on metals on which oxides are readily formed. The second property associated with an arc established in an atmosphere of inert gas is that the resistance to current flow is considerably higher when the electrode is positive than when the electrode is negative. This latter property creates some special problems in power supply for the Heliarc process.

The purpose of this article is to explain these characteristics of the arc and to show how they affect the application of the Heliarc welding process.

To establish some common ground for discussing these two properties of an electric arc in an atmosphere of inert gas, there is included a brief review of the Heliarc welding process with a description of the apparatus used and some of the more important applications.

The electrode holder for the tungsten electrode used in Heliarc welding also provides an arrangement to discharge the inert gas around the electrode and the weld. Figure 1 illustrates a typical torch and shows the method of gas distribution, electrode holder, and cooling water circulation. In operation, the electrode holder, or torch, is held in much the same manner as the blowpipe in oxyacetylene welding.

The most important function of the inert gas is to shield the weld metal and prevent contamination by oxygen and nitrogen in the air. As already mentioned, this is responsible for the outstanding advantages of the process, since it makes it unnecessary to use a flux. The fact that no flux is required is of particular advantage in the welding of aluminum. All other fusion welding processes on this metal require a flux for the satisfactory reduction of oxide and considerable work is required to remove all traces of the flux after welding.

In the welding of aluminum window sash the operator makes a fillet weld using a 3/32-inch diameter drawn-aluminum welding rod and a welding current of 170-ampere alternating current with high-frequency stabilization. The process is applied to the fabrication of aluminum beer barrels as is shown in Figure 2. The preformed barrel halves are fitted on a mandrel for machine welding the girth seam. The mandrel is removed through the opening and a forged aluminum bung is welded manually in place as shown in Figure 3.

**Figure 2. Machine welding aluminum beer barrels**

Full text of a conference paper, "Electrical Characteristics of the Arc in 'Heliarc' Welding," presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948.

H. T. Herbst is development engineer, The Linde Air Products Company, New York, N. Y.

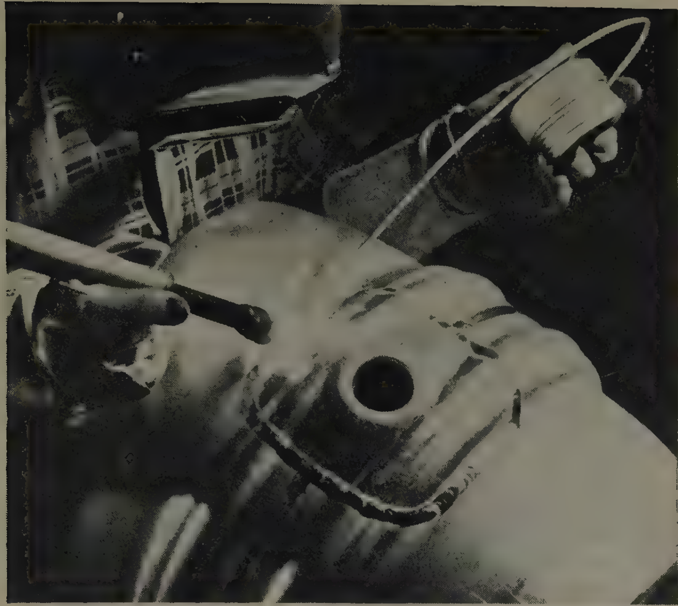


Figure 3. Manual welding the bung to an aluminum beer barrel

The Heliarc process frequently is used with direct current in the fabrication of stainless steel. Figure 4 shows a typical setup for the welding of an edge seam joining the bottom and sides of a stainless steel container. Here a shape weld is made by employing an oxyacetylene shape tracing machine.

It was mentioned previously that the cleaning action occurred in d-c welding with reverse polarity. Let us take a minute to explain the difference between straight polarity and reverse polarity.

In d-c straight-polarity welding, the electrode is connected to the negative terminal and the work to the positive as shown in Figure 5. The electron flow is therefore from the electrode to the work. Positively-charged gas ions are created in the arc and flow from the work to the electrode. The gas serves only as a shielding medium. Direct current with straight polarity is well suited for use in the Heliarc welding process when applied to such metals as stainless steel, carbon steel, copper, some copper alloys, and Inconel. This is because the normal oxide coatings of these metals do not interfere with good coalescence in welding.

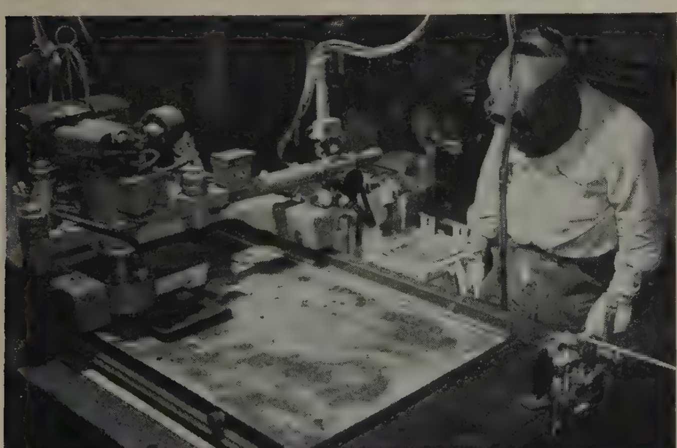


Figure 4. A templet guides the machine to the desired shape in welding a stainless steel container

Figure 5. The straight - polarity connection

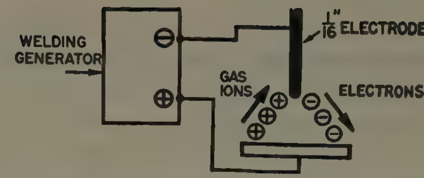



Figure 6. The contour of the straight-polarity weld

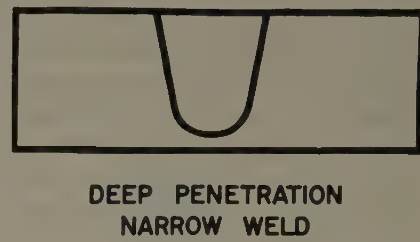



Figure 7. The reverse-polarity connection

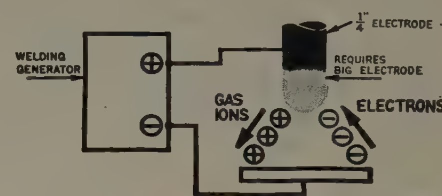
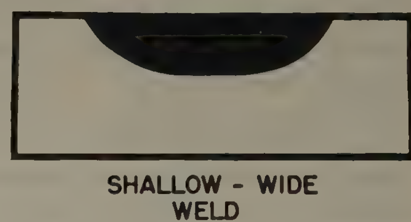



Figure 8. The contour of the reverse-polarity weld




The contour of the weld produced by d-c straight polarity is rather deep and narrow, as shown in Figure 6. The heat liberated by the arc is concentrated in the workpiece and there is relatively little heating of the electrode. When using direct current with straight polarity, an electrode 1/16 inch in diameter is sufficient for a welding current of 125 amperes.

In d-c welding with reverse polarity, the electrode is connected to the positive terminal of the welding generator and the workpiece to the negative terminal as shown in Figure 7. The electron flow is from the work to the electrode. This causes considerably more heating of the electrode. With reverse polarity (electrode positive) it takes a 1/4-inch electrode to carry 125 amperes. The contour of the weld as shown in Figure 8 is shallow and broad.

Welding with d-c reverse polarity is not generally recommended because a larger sized electrode must be used. In welding the oxide-forming metals, the arc length required is so short that it is difficult to maintain it without fouling the tip. This is particularly evident with aluminum which is attracted to the electrode. Magnesium, on the other hand, is repelled by the electrode with the result that, even though the arc length is short, it can be welded by this method.

## THE CLEANING ACTION

There is a cleaning action, particularly on certain metals, when the reverse-polarity connection is used. In trying to discover the reason for this cleaning action, we will have to examine what we know and what we believe to be taking place in the electric arc. An electric arc is a passage of

electric current through a gas. The gas is ionized and therefore consists of electrons and positively charged ions. The electrons travel from the negative to the positive poles of the arc, and the ions proceed in the opposite direction, from the positive to the negative poles of the arc. In the case of reverse-polarity welding, the electrons travel from the workpiece to the electrode while the ions will be traveling from the electrode to the workpiece.

While there is some field for debate as to just what causes the cleaning action, it is a fact that such action does take place with reverse-polarity welding and not with straight-polarity welding. Microscopic study of the cleaned area adjacent to the weld area reveals a condition similar to that produced by sandblasting. It is thought that this is the result of bombardment of the oxide layer by positively-charged gas ions in the manner of a miniature sand blast. This is supported in part by reference to the difference in amount of cleaning action obtained when using argon as compared to helium. While there is no noticeable cleaning effect when using helium, the use of argon does provide a marked cleaning effect. Thus, it would seem reasonable to attribute the cleaning action to the bombardment principle since the atomic weight of argon is some ten times greater than that of helium.

## CHARACTERISTICS OF A-C WELDING

In welding with alternating current, the polarity of the electrode and the workpiece changes at every half cycle of the current. The result is a combination of the characteristics that are peculiar to straight polarity and those at-

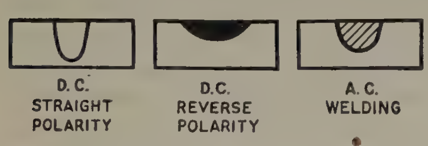



**Figure 9. The contour of the a-c weld compared with the contours of straight-polarity and reverse-polarity welds**

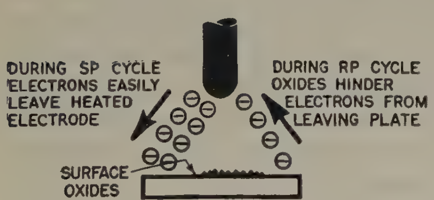



**Figure 10. The surface oxides hinder the flow of electrons leaving the plate**

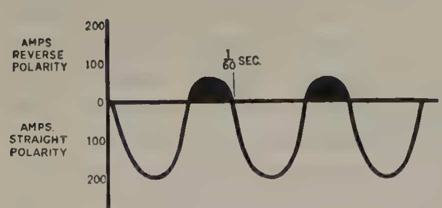



**Figure 11. The unbalanced wave results from oxide interference**

tributable to reverse polarity. The depth of melting in the workpiece is less than that obtained with straight polarity but more than would be obtained with reverse polarity Thus, the contour of the weld lies between that of the narrow, deep type produced by straight polarity and the broad, shallow type produced by reverse polarity. A comparison of the three contours is shown in Figure 9.

The amount of heating of the electrode is between that

**Figure 12. Partial rectification of the unbalanced wave**

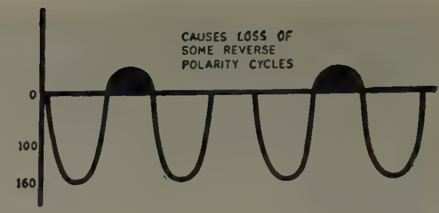



**Figure 13. Complete rectification occurs when the arc is not stabilized**

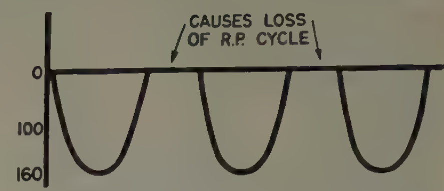
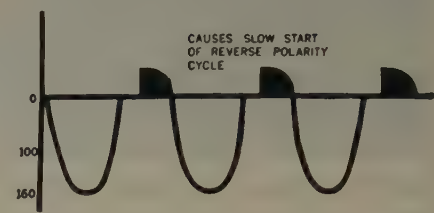



**Figure 14. Incipient rectification is caused when the high-frequency spark is not properly timed**




produced by straight polarity and that produced by reverse polarity. In welding with an alternating current of 125 amperes, a 3/32-inch-diameter electrode is sufficient to withstand melting by the heat produced. The cleaning action present with reverse-polarity d-c welding is also present in a-c welding and is sufficient to remove the oxides from metals that offer particular difficulty (aluminum, magnesium, and beryllium copper).

The use of alternating current, however, introduces another problem, namely, that of stabilizing the arc. Since the current drops to zero twice in each complete cycle, there must be some means of starting the arc again after it has been extinguished. This can be done by using a transformer that has a high open-circuit voltage or a high-frequency voltage can be imposed on the regular welding current.

In the first method, the high open-circuit voltage is sufficient to re-establish the arc after the current drops to zero. In the second method, the high-frequency discharge serves to ionize the air gap and provide a ready path for the flow of current.

## PROBLEMS OF THE UNBALANCED WAVE

In an arc in an inert atmosphere between a tungsten electrode and most metals there is a greater resistance to current flow when the electrode is positive than when it is negative, as shown in Figure 10. The unequal resistance to current flow during the two parts of the a-c cycle produces an "unbalanced wave" as shown in Figure 11. The term "unbalanced wave" is proposed to describe this condition, reserving rectification for a condition to be described later. The unbalanced wave shown may be considered a regular a-c wave plus a d-c component. If the method of stabilizing the arc is not fully satisfactory, an arc may be maintained with only the occasional loss of the reverse-polarity portion of the cycle. Such loss of occasional half cycles is illustrated by Figure 12. The term "partial rectification" is proposed to describe this situation. When there is no

attempt to stabilize the arc, it is possible that no current will flow when the electrode is positive as illustrated in Figure 13. This is called "complete rectification." When the timing of the high-frequency spark does not coincide with the beginning of the reverse-polarity cycle, only part of each reverse-polarity cycle may be lost. To describe this, the term "incipient rectification" is proposed. (Figure 14).

In our research laboratories, some motion picture footage was taken at the rate of 3,200 frames per second for the purpose of studying the arc in slow motion. When this film was projected at the rate of 16 frames per second, each complete cycle of alternating current lasted about $3^1/_3$ seconds on the screen. In this length of time it was possible to observe clearly the difference in progress of the weld during the straight- and the reverse-polarity portions of the cycle.

The straight-polarity part of the cycle appeared as a bright, white flash of flame, while the reverse-polarity portion was relatively dim and of shorter duration. During the latter, the clean zone ahead of, and alongside the weld was seen to advance. Conditions were adjusted during the exposure of the film so as to induce partial rectification. Visually this was shown by a regular series of alternate bright and dim flashes, the regularity being occasionally interrupted by the failure of a dim flash to appear.

# Magnetic Amplifiers for Shipboard Applications

L. W. BUECHLER
MEMBER AIEE

**Magnetic amplifiers are becoming more and more important in many industries. This article indicates how such desirable characteristics as ruggedness, long life, high-power possibilities, a-c operation, and practically no maintenance requirements are being applied to naval shipboard applications.**

ONLY the most reliable equipment can be tolerated in a naval vessel's electric system. Since the ship's gun controls, radar, and communication are all dependent on the ship's electric system the only thing a ship can do in case of failure of this system is retreat. It certainly could not take any active part in fighting action, in fact, a crippled ship often requires protective assistance from other ships, just when the other ships could be used most effectively elsewhere in the battle.

Keeping the ship's propulsion system operable is of prime importance if the ship is to survive. If it fails the ship becomes dead in the water and is easy prey for an enemy's guns, torpedoes, or bombs. Another very important system is the steering. Should the steering system fail the ship must stop, or run uncontrolled, usually in circles. Although great effort is devoted to making a ship's propulsion and steering not totally dependent on the electric system, often even these important systems are dependent on the ship's electric system. All large naval vessels, such as troop transports, cargo vessels, as well as combatant ships, have certain weapons, such as antiaircraft guns, which must be kept in operation; and all vessels have communication systems which are essential to their efficient operation. One of the most important of all special considerations in the design of reliable shipboard electric equipment is that of shockproofness. The mechanical shock (that is, sudden violent movement of the ship's hull and internal equipment) caused by the firing of a ship's own guns and the exploding of enemy rockets, shells, mines, and torpedoes, frequently causes extensive damage to many types of equipment.

Vacuum tubes always have been classified as a very undesirable component in a system as important as the ship's electric system. Great strides have been made in improving the ruggedness of vacuum tubes but, notwithstanding these improvements, vacuum tubes still fail too often. Contractors supplying the electric equipment often have found it difficult to accomplish various functions in equipment without using vacuum tubes. For example, in a recently developed automatic steering control, four amplifiers were required. To improve the reliability of the system, a spare set of vacuum tube amplifiers with changeover switches was provided. Frequently a loss of accuracy or performance of an item, such as a voltage regulator, has had to be permitted in order to avoid the use of vacuum tubes.

## ADVANTAGES OF MAGNETIC AMPLIFIERS

It was late in the last war that it became evident that magnetic amplifiers could be used to good advantage in many places where vacuum tubes were previously thought to be necessary. The vacuum tube may be considered as a variable resistance in a d-c circuit; whereas, the magnetic amplifier may be considered as a variable impedance in an a-c circuit. In either case a small amount of control power is used to vary the current or power in the power circuit. Magnetic amplifiers consist basically of saturable reactors and dry-disk rectifiers and can readily be made much more rugged and reliable than vacuum tubes. They already have been used in some applications and have been found to be very reliable and maintenance-free. It is desired and believed obtainable to have units which, once installed, will not require any routine service or maintenance during a service life of at least five years.

In addition to being very rugged and maintenance-free,

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**L. W. Buechler** is with the Bureau of Ships, United States Navy Department, Washington, D. C.

magnetic amplifiers are considered to offer the following:

1. They can operate from the ship's a-c supply and, for most applications, require no power supply such as the "*B*" supply required for vacuum tubes. Although the reactors used in the magnetic amplifier may weigh more than a comparable vacuum tube, the size and weight of a complete magnetic amplifier can be made equal to or less than the vacuum tube amplifier since the "*B*" power supply required with the vacuum tube amplifier is usually a large portion of the total size and weight.

2. They require no warm-up time. Components, such as gun controls, would not have to be kept continuously energized just in case they suddenly might be required.

3. They do not have the power limitations of vacuum tubes. Due to the heat loss in vacuum tubes the power output, without special cooling of the tubes and chassis, is often a limiting feature in designs. The greatest heat loss problem in magnetic amplifiers is in the rectifier. Present work indicates that rectifier efficiencies of 85 to 90 per cent are possible; the heat loss for 1- to 2-kw of output is not serious.

4. Very high power amplification per stage is possible. A power gain, that is ratio of controlled power in load to power in control circuit, of 1,000,000 to 1 or even 100,000,000 to 1 per stage is possible but not considered practical for most applications due to slow response which may range from one to five seconds. For most applications in which a response of 1/200th to 1/10th of a second is desired, a power gain of 1,000 to 1 to 10,000 to 1 per stage is considered practical. An input control signal of from one milliwatt to a few microwatts is considered sufficient to control the first stage of amplification. Smaller control signals have been used but are not considered developed to the stage where they can be used generally.

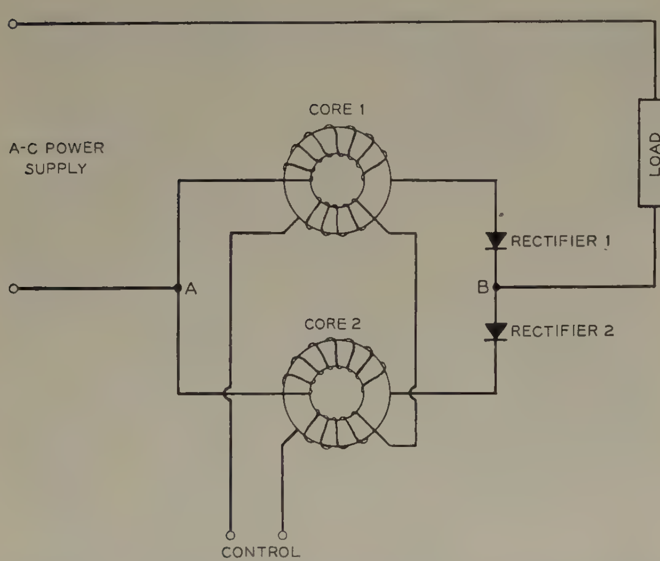


**Figure 1. Schematic diagram of a simple magnetic amplifier circuit**

5. The time of response can be made to meet most requirements. The time of response usually is measured in cycles of time referred to the a-c power supply. For power gains of 1,000 to 1 to 5000 to 1 the time of response probably will be in the order of two to five cycles. This, of course, is dependent on the magnetic material and the circuits used. For 60-cycle power the time of response will run from 1/10 to 1/30 of a second. If faster response is desired, 400-cycle power (which is becoming more available aboard naval vessels) can be used and the time of response cut to about 1/200th of a second. Special higher frequency power supplies can be used if much faster response is required, such as for an audio amplifier.

## PROBLEMS IN MAGNETIC AMPLIFIERS

It is not intended to imply that magnetic amplifiers are new. They have been known and applied for many years, beginning in about 1915. Reference 1 lists some 213 articles and patents on magnetic amplifiers and allied subjects. Several companies over the past years have used this type of amplifier in limited quantities for certain naval applications, mainly voltage regulators. In such application, the magnetic amplifier usually was developed or designed around a particular piece of equipment, and no great effort was made to develop magnetic amplifiers for general use as a possible substitute in certain applications for vacuum tubes. Reports from Germany indicated that that country had taken a much broader interest in magnetic amplifiers. This may have been due to the limited number and variety of vacuum tubes available, but they did develop and use magnetic amplifiers for applications in which we would have used vacuum tubes. Developments have taken place over the last five years which are believed to make magnetic amplifiers more promising today than they were 15 or 20 years ago. Better magnetic steels have been developed and are being made available commercially. Better rectifiers of the germanium crystal and selenium types are now available and being further improved.

A brief discussion of the simple form of a magnetic amplifier will assist in understanding how these better steels and rectifiers can improve magnetic amplifier characteristics. Figure 1 illustrates a circuit which may be used. Assuming certain idealized conditions such as perfect rectifiers, a high impedance control winding, and an idealized saturation curve, the operation can be explained as follows. During one half cycle one reactor core, core *1* in Figure 1, is inactive; the rectifier is holding back (or absorbing) the voltage which may exist between *A* and *B*. The state of saturation in the core *1* is determined by the current and turns in the control winding. During the following half cycle the rectifier associated with the winding for core *1* conducts and this winding will absorb voltage until core *1* saturates. If it saturates during this half cycle the portion of the voltage occuring after saturation appears across the load. The action on core *2* is similar but it occurs on the alternate half cycle. The voltage appearing across the load is alternating and of a shape somewhat similar to that which would be encountered with a grid-controlled thyratron tube in place of reactor core and rectifier.

Assuming the saturation curve has the shape shown by the solid line in Figure 2, the maximum voltage which can be absorbed across the power winding core *1* during its conducting half cycle would be caused by a flux change from the point *C* to the point *D* on the saturation curve. In order for the flux to start at point *C* there must be sufficient negative bias caused by the control current to bias the core during the nonconducting half cycle to the point *C* on the saturation curve. If a flux change of *C* to *D* is sufficient to equal the applied alternating voltage, practically no voltage will appear across the load when the cores are biased to the point *C*; and practically full voltage will appear across the load when the cores are biased to the point *D*. In actual practice the saturation curves do not have such sharp corners; curve *3* in Figure 2 is a more typical saturation

curve. The curve shown in Figure 3 represents the output curve obtained for one particular magnetic amplifier. It will be noted that approximately minus ten milliamperes is required to give negligible voltage across the load and plus ten milliamperes gives 34 volts across the 50 ohm load. The remainder of the applied 65 volts at plus ten milliamperes control current is lost primarily in resistance drop in the load winding, rectifier drop, and reactive drop in the cores due to the fact that the cores did not saturate sharply at plus ten milliamperes.

## MAGNETIC MATERIALS

Some features about the magnetic cores which can be noted from the foregoing are

1. The steel should saturate at as low a magnetizing force as possible as this will require less power in the control winding. The maximum permeability alone of the steel is not necessarily a good measure of the steel quality. Curves *1*, *2*, and *3* of Figure 2 might all have the same maximum permeability but give entirely different results when used in the magnetic amplifier. Permeability is usually an indication but not a measure of the power gain obtainable per stage.

2. The steel should have a very sharp knee on the saturation curve and the knee should occur as near maximum flux density as possible. Any additional flux after passing the knee of the curve causes induced voltages which makes it impractical to obtain anywhere near maximum voltage across the load. Very high values of magnetizing force are present on the core during the conducting half cycle. For example, with plus ten milliamperes, or 0.5 ampere-turn in the control winding of the magnetic amplifier illustrated in Figure 3, the maximum magnetizing force on the core during the conducting half cycle is about 700 ampere-turns. The saturation curve, therefore, should be flat from the knee to 700 ampere-turns.

3. The steel should have as high a flux density at saturation as possible. This permits smaller cores for the required voltage. In general the higher flux density steels, namely the silicon steels, do not have high permeability nor sharp saturation; therefore, the

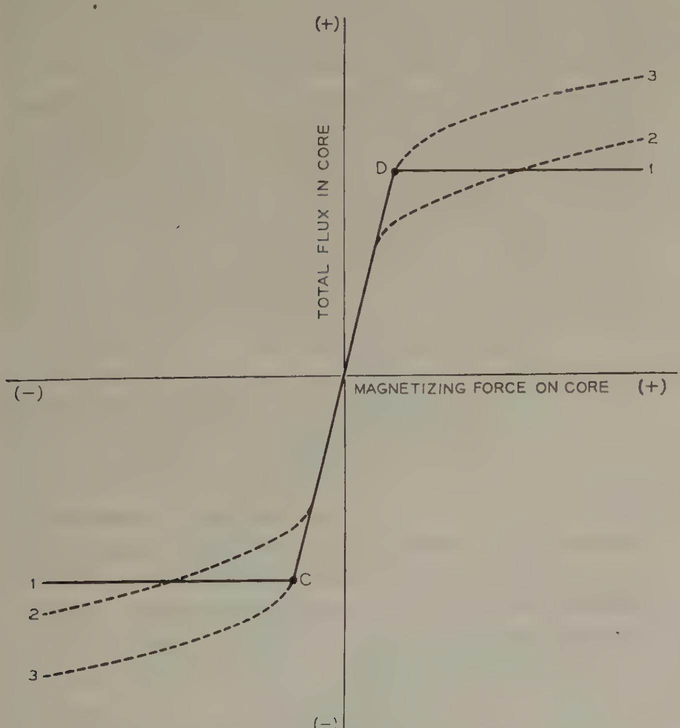


**Figure 2. Hypothetical saturation curves (hysteresis effects neglected)**

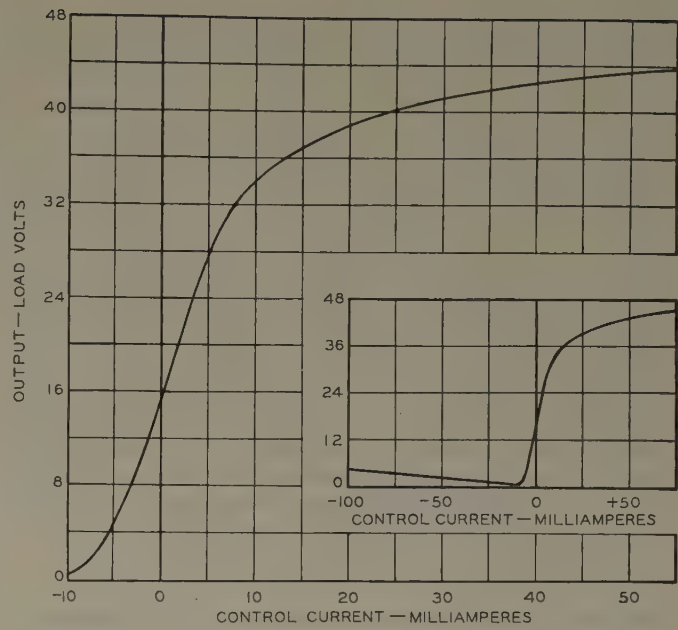


**Figure 3. Output characteristics of a magnetic amplifier**

*Connections: See Figure 1*
*Winding: (each core)*
*control—50 turns number 32 wire, 1.9 ohms*
*output—700 turns number 30 wire, 14 ohms*
*Load: 50-ohm resistor*
*Power input: 65 volts, 400 cycles*
*Core: HiMu number 80, 0.006 inch*
*Ring laminations—$^3/_4$-inch inside diameter, $1^1/_4$-inch outside diameter, $^4/_8$-inch stack*

nickel alloy steels often are required notwithstanding their lower flux densities.

4. The steel should be consistent so that the two or more cores which make up the amplifier will be similar for best performance and so that various amplifiers made to the same specifications will have similar characteristics. Lack of consistency of magnetic materials has been the greatest problem to date in the magnetic amplifier program. A deviation of not greater than plus or minus ten per cent in the magnetic characteristics would be considered very good. A deviation of ±20 per cent would be acceptable and much better than commercially available in the higher permeability materials.

5. The steel losses should be small. Eddy currents in the steel not only cause power loss but also cause the amplifier to have slower response. Hysteresis losses in addition to causing power losses may have the undesirable effect of causing a hysteresis effect on the input-output characteristic of the amplifier, that is, the output power may be different depending on whether the control is increasing or decreasing.

Developments in the field of magnetic materials which appear to have promising applications in magnetic amplifiers are as follows (Figure 4 illustrates magnetization curves for materials discussed):

1. The grain-oriented silicon steels. These have much higher permeabilities and sharper saturation than ordinary silicon steels. They should be particularly useful in power applications where the cost per pound of steel is an important factor.

2. The magnetically heat treated silicon steels. These steels have similar features and advantages of the grain-oriented steels with the additional feature that more freedom in the choice of core structure is available since stamped laminations can be used.

3. The 50 per cent nickel iron alloys which are now standard items with some steel companies. These have higher maximum permea-

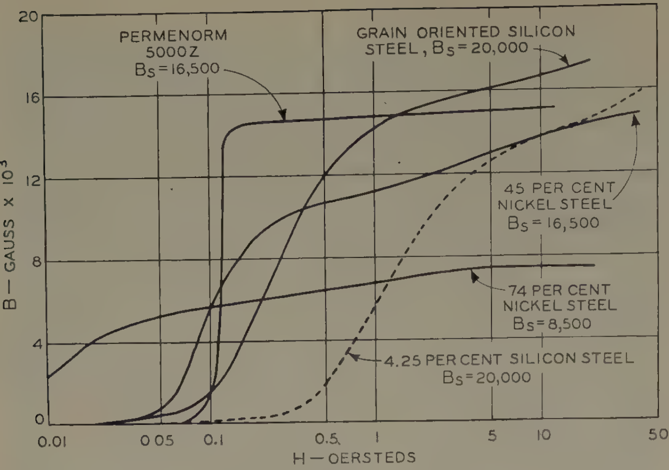


**Figure 4. Normal magnetization curves for various steels which may be used in magnetic amplifiers**

*Data from tests by Naval Ordnance Laboratory*

bilities than the grain oriented or magnetically heat treated steels but are more expensive and have lower flux density at saturation than the silicon steels; therefore, their use will tend to be limited to applications in the low and intermediate power stages.

4. The 74 to 80 per cent nickel iron alloys which are also commercially available. These are more expensive, have lower flux density at saturation, and have a higher maximum permeability than the 50 per cent nickel iron alloys. Although their use may be limited to low power stages, they are useful for working at lower control signal inputs than any other commercially available steel.

5. The Supermalloy magnetic material developed by the Bell Telephone Laboratories but which is not yet commercially available. This material which has the highest permeability of any present material (about 1,000,000) should, when commercially available, permit working at signal levels even lower than can now be done.

6. The Permenorm-*5000Z* type of material. This material has a rectangular hysteresis loop (See Figure 5) and was originally developed by the Germans for mechanical rectifiers. It has the very desirable characteristic of saturating sharply at a low magnetizing force (about 0.15 oersted). The Naval Ordnance Laboratory has succeeded in developing a superior heat treatment process for this material and several companies are working on the problem of producing it commercially. Since it contains about 50 per cent nickel and is more expensive than other 50 per cent nickel alloys, its use probably will be restricted to low power and intermediate power stages.

## RECTIFIERS

High quality rectifiers are essential in magnetic amplifiers. Some features desirable in the rectifiers are

*Low forward resistance.* This is desirable in order that the power loss and the voltage drop will be kept to a minimum.

*Very low back leakage.* A check on the magnetic amplifier in Figure 3 will illustrate the magnitude of this problem. During the conducting half cycle with a control current of ten milliamperes (0.5 ampere-turn), the rectifier carries a maximum peak current of about 1.0 ampere. With minus ten milliamperes of control current a large portion of the alternating voltage of 65 volts rms appears across the rectifier. A back leakage in the power circuit of 0.1 per cent would amount to a peak of about 0.001 ampere or 0.7 ampere-turn, whereas, the control ampere-turns are supposed to be only ±0.5 ampere-turn. The actual effect of leakage depends on the incremental hysteresis loops, operating point on the load curve, power circuit inductance, and so forth; and usually is less than indicated by this simple calculation. The leakage increases the amount of control current required and somewhat decreases the negative bias required resulting in an overall loss in power gain.

*Very stable characteristics.* Any change in the rectifier's operating characteristic changes the performance of the magnetic amplifier in which it is used, especially if the rectifier has or develops leakage. Special consideration to the inverse voltage rating must be given in order to obtain the most stable operating characteristics. Consideration also must be given to the effect of moisture and temperature on rectifier characteristics. It is expected that the moisture problem will be avoided by using hermetically sealed rectifiers, probably enclosing them in the same container with the cores.

## CIRCUITS

Various electric circuit arrangements are possible with magnetic amplifiers but will not be discussed since circuits are beyond the scope of this article and circuits have received considerable discussion in the literature.[1-5] The particular circuit to be used will depend to a large extent on whether single-phase or 3-phase alternating power is available, whether a-c or pulsating d-c output is desired, whether the load is resistive or inductive, and the response time constant required. The magnetic circuit is very important and must be carefully designed if full advantage of the magnetic properties of the steel is to be realized.

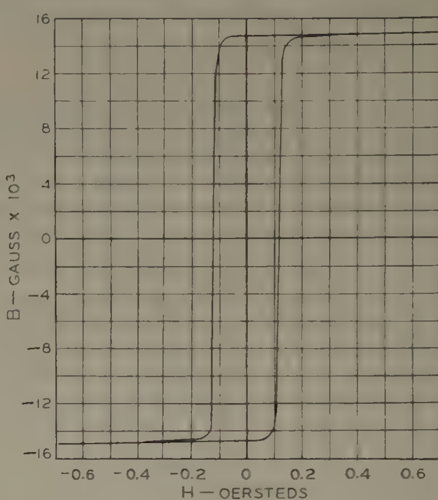


**Figure 5. Hysteresis loop for Permenorm 5000Z steel**

*Data from tests by Naval Ordnance Laboratory*

For larger power applications, stacked laminations using air gaps may be necessary for most economical production and a sacrifice in gain or time constant caused by an air gap in the circuit has to be permitted. For most low-power amplifiers it is considered that a closed magnetic path is essential. One solution is the use of stamped-ring laminations and a toroidal winding. Thin strip laminations in the form of tape wound into a circular core also has been found satisfactory and about equivalent to the stamped ring cores. This form of core is necessary in using the Permenorm *5000Z* and other grain oriented material.

The stamped laminations as illustrated in Figure 6 give good results when used in magnetic amplifiers. For the rectangular lamination, a split winding-bobbin is placed on the center leg and all windings placed on this leg. This arrangement has advantages over the toroidal winding using the ring lamination since it permits winding a larger number of turns resulting in economical production of higher impedance windings; it permits obtaining a better copper space factor; and the winding does not stress the magnetic core. On the other types of cores, special core boxes may be required to prevent stressing the core and destroying the good magnetic properties of the core material.

## TIME CONSTANT

The time constant of response for the majority of magnetic amplifiers is dependent to a great extent on the inductance of the control winding. The time constant of the control winding can be controlled best by using magnetic materials and magnetic circuits which require a very small amount of control power. Fewer turns and more resistance in the control winding then can be used to reduce the time constant of the build-up of current in the control winding.

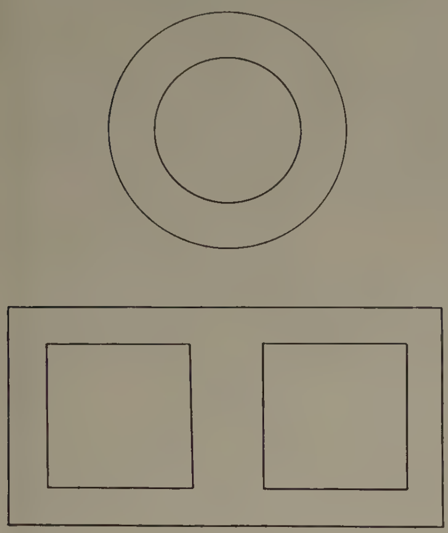

**Figure 6. Core shapes used in magnetic amplifiers**

Somewhat the same effect can be obtained by the use of negative feedback with the additional advantage of improving the linearity of the response. Both control winding resistance and negative feedback involve sacrificing gain to reduce the time response. Since gains of many thousand or even several million per stage are obtainable, reducing the gain to shorten the time constant is not as undesirable as might at first be thought. As indicated previously time constants of two to five cycles with a power gain of 1000 to 1 to 5000 to 1 per stage are considered to be reasonable values.

## APPLICATIONS

In general, magnetic amplifiers are believed to be usable for many applications where vacuum tubes presently are required and used. They are not believed to be usable in their present form at radio frequencies due to high eddy current losses in the core. At present 0.001- to 0.002-inch thickness is about the thinnest laminations which are obtainable commercially in high permeability magnet material. Further development and use of ferrite materials may permit magnetic amplifier work at high frequencies.

Some naval shipboard applications for which magnetic amplifiers may be used include the following:

*Voltage regulators.* As indicated previously, there already has been applications along this line, and it is believed that a larger use of magnetic type amplifiers will be made in future regulators.

*Speed and frequency regulators.* The amplifier can take the speed (or frequency) signal and amplify the signal to control the prime mover to the desired speed. Developments of this nature are in process.

*Line to line voltage regulators.* Magnetic amplifiers already are being applied for this purpose, and, as voltage requirements become more stringent, this application will probably grow.

*Automatic battery charger controls.* Limited applications of magnetic amplifiers in this respect already have been made and others are now under consideration.

*Servo amplifiers.* This use is probably one of the broadest fields for magnetic amplifier application. Many servo systems aboard ship require amplifiers where the response time of a magnetic amplifier would be satisfactory. The Germans thought this application was very promising and actually used magnetic type of amplifier for a number of shipboard servo systems.[4]

*Instrument amplifiers.* On several occasions the need has arisen for an amplifier to take very low level signals and amplify them to the point where they can be used to operate a meter of shockproof design.

*Audio amplifiers.* By using an a-c power supply of 10,000 to 20,000 cycles, magnetic amplifiers appear to hold considerable promise of producing a high power, light weight, amplifier for this application. The main problem is in generating the high-frequency power supply. Motor generators appear to be the quickest solution to this problem, but other methods not employing vacuum tubes are under consideration.

*Control relays.* Magnetic amplifiers can find use in some of the metering on detecting circuits and in eliminating auxiliary control circuit relays.

*Other miscellaneous applications.* Devices such as temperature regulators, time delay elements, modulators, current regulators, also provide applications for magnetic amplifiers, although at present little developmental work is underway for these particular applications.

## DEVELOPMENTAL PROGRAM

At present, considerable effort in the form of laboratory projects and contracts, is being expended to develop the theory and design principles of magnetic amplifiers, to develop magnetic materials which best will meet the needs of the amplifiers, to develop rectifiers of suitable characteristics, and to develop the amplifiers for certain applications in which their use appears advantageous. The progress of this work has been slow and most of the results of the investigations are not presently available; therefore much of this summary has had to deal with only the general results. Several applications not mentioned herein have been made in classified equipment and cannot be discussed.

It is hoped that eventually various types and sizes of magnetic amplifiers can be made available for general use so that they will not have to be designed for each application The application then can be designed to use the type and size which most nearly meets the requirements of the job.

The work to date has confirmed earlier beliefs that magnetic amplifiers can be used for many shipboard applications wherein previously only other devices, such as relays or vacuum tubes, were considered practical. The ability to make magnetic amplifiers very rugged and service-free is considered to be of very great value to the Navy, especially for important circuits or systems in which reliability and continuity of service are of prime importance.

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# Metropolitan Electric System Development

M. L. WARING
MEMBER AIEE

SINCE 1928 the electric load of metropolitan New York has more than doubled. Served at the beginning by individual companies, the Consolidated Edison System is now completely integrated, operating all but three city-owned power stations in the area. The development of the Edison system has been a gradual process guided by these general fundamental policies:

First, to maintain a margin of reserve capacity, determined by probability and designed to provide a minimum but adequate degree of reliability. Figure 1 summarizes system-reserve-calculation results for today and for 1952 after new unit construction. Present plans call for maintenance of 430,000-kw total reserve capacity, about 16 per cent of the 1952 peak hour load.

Second, to expand and modernize existing low-pressure generating stations by installing topping turbines and associated high-pressure boilers. The new Waterside station (Figure 2) will have a combined generator rating of 658,200 kw, an 80 per cent increase over 1934 station capacity. Also, the station heat rate will improve from 25,000 to 11,000 Btu per kilowatt-hour. Ten topping turbines with a combined capacity of 556,000 kw are now in service or being installed in the system. All other contemplated capacity installations will be of the full expansion type.

Third, to reinforce the tie feeder system interconnecting generating stations when required to minimize the over-all system reserve capacity, but to install topping turbines, whenever practicable, as the first means for providing additional capacity needed by local areas or parts of the system. With the near completion of the topping program, installation of large capacity ties between generating stations is being accelerated.

Fourth, to segregate the secondary network system into isolated areas, each fed independently from a single switch gallery and limited to a load size reenergizable in the event of a shutdown. Because of segregation, area distributing stations can be installed adjacent to the load center supplied from the high-voltage tie feeder system. Two such stations, now under construction, will supply the bulk of the load in the Borough of Queens.

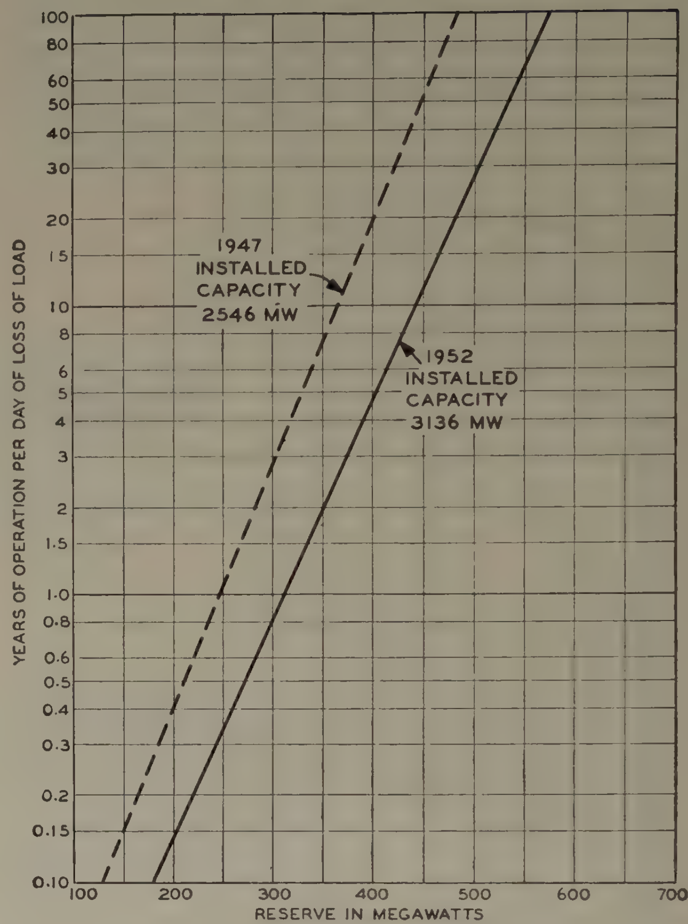
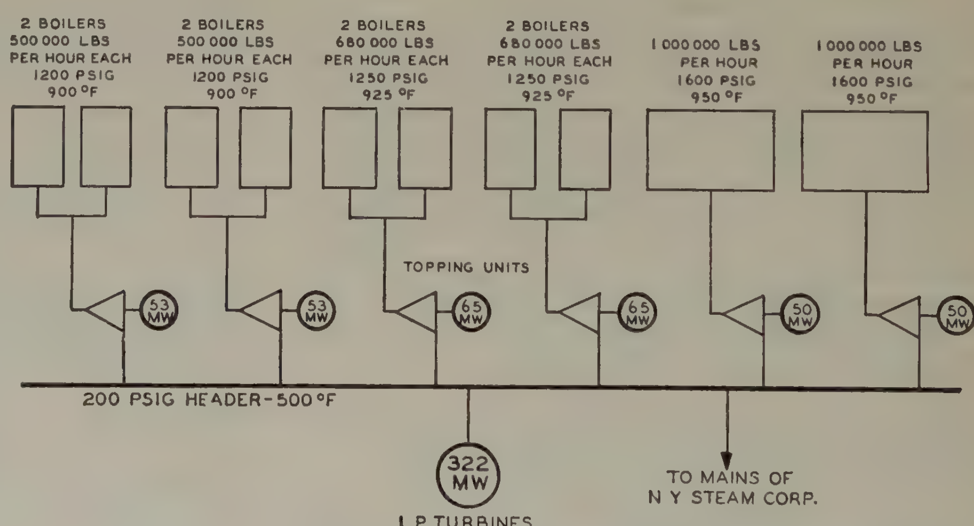



**Figure 1. Years of operation per day of loss of load as a function of reserve in megawatts**

**Figure 2 (to side). Schematic diagram, Waterside station boiler and turbine equipment after completion in 1949 of construction program**




Digest of paper 48-266 "Planning the Developmen tof a Metropolitan Electric System," recommended by the AIEE system engineering committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**M. L. Waring** is planning engineer in the system engineering department of the Consolidated Edison Company of New York, Inc., New York, N. Y.

# Military Teletypewriter Systems

F. J. SINGER
MEMBER AIEE

AT THE OUTBREAK of World War II there was a sudden and urgent demand by our Armed Forces and Government officials for accurate secret and reliable world-wide communication networks. These were required to permit close co-ordination between all echelons and to permit handling the stupendous traffic required in conjunction with tactical, supply, and administrative problems, as well as affairs of State. This challenge was met through efforts of Bell System engineers, working closely with the Armed Forces, by providing secret teletypewriter means of communication over wire-lines and radio networks on a world-wide basis.

Perhaps the outstanding contributions during the early period of the war in this field were the development of two alternative systems to permit the reliable use of transoceanic high-frequency radio links for teletypewriter traffic. One of these systems, known as the *AN/FGC* type (Figure 1) provides a single 2-way radio teletypewriter facility. The other, a multichannel system, makes use of single sideband twin-channel radiotelephone and carrier telegraph equipments together with additional components to make the system suitable for reception of teletypewriter signals. A common military application of this system included six telegraph channels applied to one of the sidebands of the twin-channel radiotelephone system with the other sideband available for telephone, giving a teletypewriter traffic-carrying capacity of about 5,000 100-word messages per day in each direction.

Other important arrangements made available during the war and becoming an essential part of these networks included several designs of militarized teletypewriter instrumentalities, teletypewriter sets, repeaters, switchboards, multichannel carrier telegraph terminals, and arrangements to adapt amplitude modulation and frequency modulation telephone-type radio sets to teletypewriter use.

As all of the foregoing arrangements became available, long- and short-haul radio links could be operated in tandem with wire-line circuits and with the private-line and *TWX* networks in the United States thus making possible several world-wide circuits. Toward the end of the war use was made of these communications to provide practically instantaneous communication between groups separated by thousands of miles.

Looking at the matter broadly, it may be said that the long-haul teletypewriter systems provided outstandingly reliable, rapid and secret communication facilities which were found by the Armed Forces and Government officials to be much better suited for providing extensive military communication networks than alternative arrangements. Each teletypewriter channel usually operated at a rate of only 60 words per minute, compared with the much higher speeds of some automatic Morse channels. Experience demonstrated, however, that as much or more traffic could be handled each day over a single teletypewriter channel as over a single high-speed automatic Morse circuit because the new method of transmission is so superior that the teletypewriter traffic flows at a uniform rate hour after hour with few if any interruptions and enciphering and deciphering may be automatic and instantaneous.

Digest of paper 48-251, "Military Teletypewriter Systems of World War II," recommended by the AIEE communication committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**F. J. Singer** is with the Bell Telephone Laboratories, Inc., New York, N. Y.

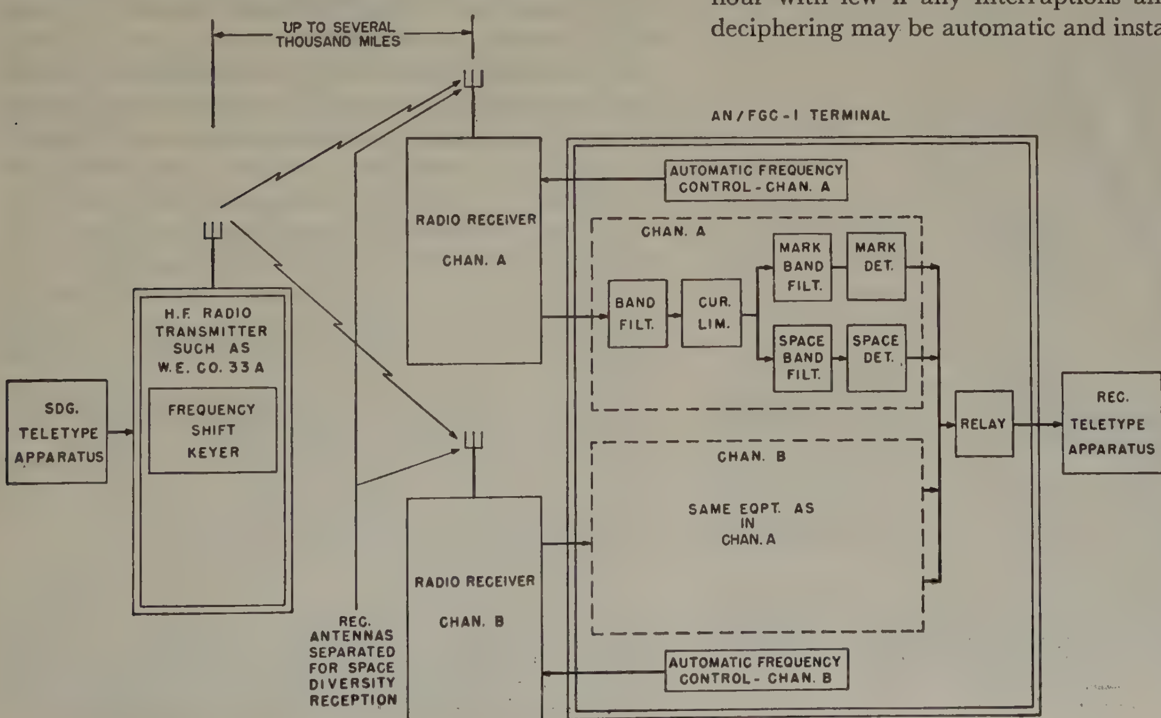



**Figure 1. Single-channel frequency shift long-haul radioteletypewriter link using AN/FGC-1 terminal equipment**

# Insulator Surface Contamination

H. A. FREY
MEMBER AIEE

ONE OF THE major unsolved problems in the insulation of electric power lines is that of obtaining trouble-free operation under conditions of severe atmospheric contamination. The presence of conducting film on the surface of outdoor insulators subjected to high voltage leads to a number of serious results. This may be summarized briefly as follows:

1. Charring or burning of wood insulator pins, cross arms, or poles may be caused by the passage of excessive leakage current over the dirty insulator surfaces.

2. Flashover of the insulator, and consequent loss of service, may result from the distortion of voltage gradients by surface dirt.

3. Insulators may be punctured progressively due to excessive local heating caused by leakage currents and sparking.

4. Corrosion of metallic members adjacent to insulator surfaces may be accelerated greatly.

Most of the dirts which commonly are deposited on insulator surfaces are very poor conductors, and cause little or no trouble so long as they remain dry. In the presence of moisture, however, the soluble elements in the dirt produce conducting electrolytes. The inert matter which is not soluble, acts as a binder to hold the electrolyte on the surface and to increase the effective thickness of the moisture film. In general the severity of any particular type of dirt will be determined by the quantity of soluble matter present which is capable of forming a conducting electrolyte and by the bonding or caking properties of the inert phases. The quantity of dirt which accumulates on insulator surfaces is controlled by the rate of deposit, the frequency and intensity of washing rain and wind, and the nature of the dirt—its ability to bond to the surface and resist washing. As a result of the conductivity of surface films, the leakage currents flowing over dirty moistened insulators may be of the order of one million times those which flow through clean dry insulators.

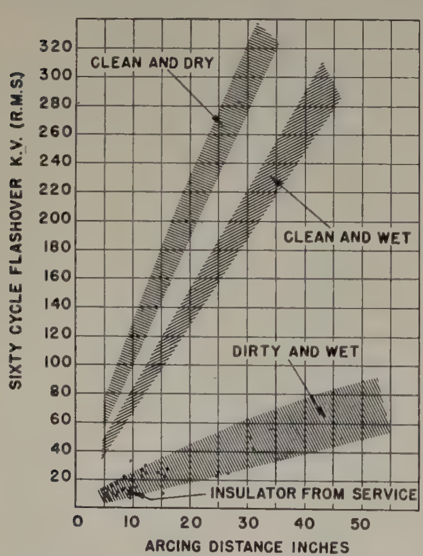



**Figure 1. Sixty-cycle flashover voltage of dirty insulators, various types and sizes, plotted as a function of the arcing distance**

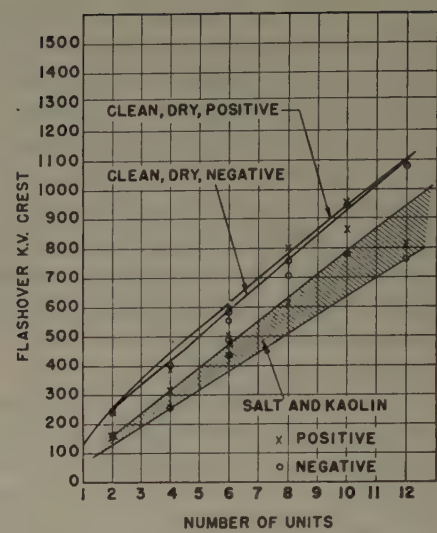



**Figure 2. Impulse flashover of dirty $5^3/_4 \times 10$ inch suspension insulators**

In the presence of moisture the 60-cycle flashover of dirty insulators is reduced drastically. The amount of this reduction depends upon the severity of the dirt and moisture film which is present. Laboratory tests have been made on insulators of various types with surfaces contaminated to a degree believed to be representative of the worst probable service conditions. The summarized results of the tests on all of the insulator types are plotted in Figure 1 as a function of the arcing distance of the various units. The composite dry and wet flashover bands for clean insulators are included in Figure 1 for comparison.

The impulse flashover voltage of insulators also is reduced by surface dirt and moisture. In Figure 2 the impulse flashover of very dirty moist suspension insulators is plotted as a function of arcing distance and in comparison with the impulse flashover of dry insulators. These tests were made with a $1^1/_2 \times 40$ microsecond standard wave. For operation in dirty areas, the following conclusions seem pertinent:

1. Overinsulate—insulators several steps larger than usual may be required.

2. Standard insulators of proper size are usually preferable, but in some cases special fog-type insulators are required.

3. Use conducting insulator pins and bonded cross arms to prevent burning.

4. In very dirty areas wash insulators periodically.

5. Planned impulse insulation levels may be adversely affected by dirt.

6. Predetermination of proper insulation for dirty areas is possible only through the experience of the operator in that area. There is real need for a method of measuring the severity of an exposure so that intelligent predetermination of required insulation can be achieved.

Digest of paper 48-255, "Insulator Surface Contamination," recommended by the AIEE transmission and distribution committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

H. A. Frey is with Locke Incorporated, Baltimore, Md.

# Telemeter Carrier Channels

T. DeWitt TALMAGE
MEMBER AIEE

THE POWER SYSTEM operated by the Tennessee Valley Authority is centrally located in the vast network of power systems serving the south Atlantic and central United States and its generation, furnished by 32 major plants, represents about 14 per cent of the total interconnected pool capacity. The Authority's 6,666-mile transmission system is interconnected with neighboring power companies by 17 major transmission lines at 12 locations. For efficient control of generation and tie-line loadings, it has been found imperative to furnish the power system load dispatchers with a clear picture of power flowing at vital points. To secure maximum benefits from the intersystem tie lines, 68 carrier terminals are installed at 25 locations to establish the major portion of a 6,500-mile telemeter and automatic load-frequency control system. The quantity and direction of power flowing in the intersystem tie lines is telemetered an average distance of 172 miles to an operating office where the tie-line loadings are totalized.

Based on a net interchange quantity, deviation-from-schedule control signals, on a time-duration impulse basis representing kilowatts, are sent by a frequency-shift power-line carrier system to 12 major hydroelectric generating plants to regulate generator governors automatically in response to load and frequency changes on the tie lines. Two separate master control carrier channels are used with one serving seven and the other eight hydroelectric generating plants having a nameplate capacity of 1,358,000 kw which represents one-half of the total generating capacity operated by the Authority.

Both telephone-line and power-line carrier equipment are used for telemetering, with the latter predominant. Intersystem telemetering makes use of both multitone amplitude modulation and frequency-shift power-line carrier channels. The frequency-shift carrier equipment was chosen for its ability to overcome high attenuation and noise level because these intercompany routes range from 120 to 220 miles long.

For intrasystem telemetering, joint use of power-line carrier pilot relay channels, averaging 62 miles in length, is made in four cases with the protective relays having preferential use of the channel. Eight telemetering channels, averaging 100 miles in length, are provided by amplitude-modulation power-line carrier apparatus. Over one 120-mile route with two intermediate by-passes, audio tones are used to frequency-modulate, on a one-to-one deviation ratio basis, power-line carrier equipment for telemeter service where the noise level interfered with the operation of amplitude modulation equipment installed initially. Four intrasystem telemetering channels are established by frequency-shift power-line carrier equipment over distances ranging from 80 to 100 miles.

**Table I. Telemeter, Load-Frequency Control Statistics (1948)**

| Kind of Apparatus | Quantity | Channel Mileage |
|---|---|---|
| **Telemeter:** | | |
| Jointly-used P.L. carrier pilot relay sets | 10 | 306 |
| P.L. carrier frequency-shift transmitters | 9 | 1,191 |
| P.L. carrier frequency-shift receivers | 9 | |
| P.L. carrier audio-tone a-m transmitters | 8 | 3,291 |
| P.L. carrier audio-tone a-m receivers | 10 | |
| P.L. carrier audio-tone f-m transmitter | 1 | 480 |
| P.L. carrier audio-tone f-m receiver | 1 | |
| Telephone-line carrier transmitters | 2 | 266 |
| Telephone-line carrier receivers | 2 | |
| Telephone cable circuits | 10 | 154 |
| Telemeter instruments | 62 | .. |
| **Load-frequency Control:** | | |
| Jointly-used P.L. carrier pilot relay sets | 2 | 49 |
| P.L. carrier frequency-shift transmitters | 2 | 771 |
| P.L. carrier frequency-shift receivers | 12 | |
| Telephone cable circuits | 3 | 20 |
| Telemeter instruments | 15 | .. |
| **Totals:** | | |
| Carrier transmitters and receivers | 68* | 6,528 |
| Telemeter instruments | 77** | .. |

P.L.—power line.
* Ten carrier sets are owned by others.
** Eight telemeter instruments are owned by others.

Table I lists the channel mileage established by each kind and quantity of equipment for the telemetering system totaling 5,688 miles, and the load-frequency control system, totaling 840 miles.

The entire power-line carrier system in operation and under construction in the Tennessee Valley region including telephone, pilot relay, remote and supervisory control, telemeter, and load-frequency control terminals is in excess of 300 carrier sets at 70 locations and makes use of 160 carrier frequencies. The use of carrier-line traps has allowed the establishment of a greater number of carrier channels than otherwise would be possible.

The phase wires to which all power-line carrier telemeter channels are coupled are trapped at both the transmitting and receiving ends as well as at intermediate by-pass points. This gives maximum stability to the carrier channels, permits most efficient use of the carrier signals, and blocks out noise from adjacent power circuits.

The use of carrier line traps, low-power carrier transmitters, and judicious choice, spacing, and location of carrier frequencies has kept inter and intrasystem interference to a minimum.

Close co-operation among members of the interconnected power systems in the southeast region in making joint carrier tests and studies and taking part in intercompany engineering discussions on the assignment of power-line carrier frequencies has been an invaluable aid in designing the carrier systems. These facilities provide a high degree of operating flexibility and insure maximum efficiency in generating and controlling power.

Digest of paper **48-262**, "Carrier Channels for Telemetering," recommended by the AIEE carrier current committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**T. DeWitt Talmage** is principal communication and signal engineer in the power engineering and construction division of the Tennessee Valley Authority, Chattanooga, Tenn.

# History of the Operational Calculus as Used in Electric Circuit Analysis

THOMAS JAMES HIGGINS
MEMBER AIEE

**Called one of the most important mathematical advances of the last quarter of the 19th century, operational calculus has become a very useful and powerful tool in modern circuit theory, servomechanisms, and transient analysis. This summary survey gives the development and cites the present status of the subject, pointing out the fundamental differences between the more common types of operational calculi currently in use.**

"LOOKING BACK on the controversy after 30 years, we should now place the operational calculus with Poincare's discovery of automorphic functions and Ricci's discovery of the tensor calculus as the three most important mathematical advances of the last quarter of the 19th century. Applications, extensions, and justifications of it constitute a considerable part of the mathematical activity today [1930]—." E. T. Whittaker.[49]

## INTRODUCTION

As commonly used, the term "operational calculus" implies those different methods of obtaining a solution of a set of differential equations whereby satisfaction of the specified boundary conditions is incorporated automatically in the course of solution. Until the mid 1930's the methods most used in electric circuit analysis were rather distinct in technique, thus were distinguished readily by name of their original proponent or by a term coined by him: Heaviside's "operational calculus," Jeffreys' "operational method," Bromwich and Wagner's "use of contour integration," and Carson's "infinite integral theorem." But after Levy, March, Van der Pol, and others had stressed, in the late 1920's, the connections linking the Bromwich-Wagner and Carson approaches, these have come to be considered as two phases of a more general attack which has been variously styled "modern operational calculus," "use of Laplace transform theory," "application of the Mellin inversion theorem," and yet otherwise.

In consequence of this consolidation, three methods are now in general use: The Heaviside operational calculus,[1–11] Jeffreys' operational method,[12–14] and that utilizing Laplace transform theory.[15–37] Of these, it can be said in general that:

(*a*). The first is not rigorously founded; is now obsolescent, being used primarily by those who studied it in the 1920 and 1930's and have not since learned the rigorous Laplace transform theory; and the teaching of it should be abandoned.

(*b*). The second, though a powerful and rigorously based method, is little known outside of England where it is used and recognized principally by Jeffreys and his students (thus, despite its title the technique displayed in reference 13 is actually that of Jeffreys' operational method). However, knowledge of it should be possessed by all interested in circuit analysis.

(*c*). The third is used largely by the younger writers on communication circuit theory and most workers doing significant research in electric circuit analysis in general, and the study of it now should be an integral and required part of the training of, at least, all graduate students in electrical engineering.

## THE HEAVISIDE OPERATIONAL CALCULUS

Though Heaviside[38–52] made significant theoretical contributions to numerous phases of electrical communication theory, perhaps his name is best known to the present-day electrical engineer through his operational calculus. In a pithy chronological summary of the course of symbolic methods of solving differential equations E. T. Bell[53] characterizes Heaviside's analysis as "the last notable advance in the symbolic method." Bell's delineation of the various regard in which Heaviside's calculus has been held over the years since its formulation is particularly amusing and interesting.

McLachlan[54] has summarized Heaviside's main contributions to his operational calculus as: incorporation of the initial conditions in the course of solution; use of the substitution

$$\left(\frac{d^v}{dt^v}\right)\equiv p^v$$

expansion in inverse powers of $p$ and "algebrisation" using the formula

$$p^{-v}\supset t^v/\Gamma(1+v)$$

expansion in ascending fractional powers of $p$ and use of the formula to obtain an asymptotic series; the expansion theorem.

Though the course of development of the other features evidently can be readily traced in Heaviside's books, it often is remarked that it is not known how he first developed this expansion theorem. In an effort to fill this gap Murnaghan[55–7] and others have pointed out how easily he could have come to it if he had possessed sufficient mathematical knowledge, and at least one writer[58] has advanced the details of a rather condensed proof that Heaviside himself gave. Now, contrary to widely held opinion[59] ("Self-taught and working in isolation, he not only took no trouble to conform with recognized mathematical methods, but even seemed to take a delight in apparently unsound arguments") it is obvious from certain

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**Thomas James Higgins** is professor of electrical engineering, University of Wisconsin, Madison, Wis.

of his published private correspondence, from inspection of his work, and from names of the various writers cited in his papers that Heaviside, though self-trained, yet had a considerable appreciation of the advantages to be derived from a well founded and formal mathematical training, and had endeavored to rectify his own lack of such training by thorough study of those branches of mathematical theory that bore on his own analytical work, at least in so far as this theory was displayed in the major mathematical texts then in print. Beyond doubt, at a quite early stage in his self-study he became familiar with one or the other of the partial fraction representations of a quotient of two polynomials as a sum of quotients involving ratios of the form $p/(p-p_i)$ or $1/(p-p_i)$. And as operational solution of these two simple expressions certainly would be among the first studied, it long has seemed to the writer that Heaviside originally might have obtained his expansion theorem by simple conjunction of these two bits of knowledge. Indeed, such derivation is outlined in a footnote on page 226 of volume 2 of "Electrical Papers." This footnote to a paper originally published in 1886 was added at the time of preparation of the volume for publication (in 1892). However, this scheme of derivation is that suggested in reference 3 published in 1893; and this reference, in turn, encompasses mostly material worked out years previously. But whether or not this conjecture is true, it is yet a fact that a very condensed derivation of date 1887 appears on page 273 of volume 2 of "Electrical Papers." Hence it would seem quite contrary to fact to state, on the basis that no derivation accompanies statement of it on page 127 of volume 2 of "Electromagnetic Theory" published only in 1899, that it is not known how Heaviside developed his expansion theorem.

Exposition of Heaviside's operational calculus is the central topic of a number of books.[4–11] But as displayed in his books, Heaviside did not systematically and rigorously develop his calculus from firmly grounded postulates, but rather (as he himself testifies) developed it empirically as he worked, points in doubt to him being settled by checking known exact solutions against corresponding operationally obtained solutions. In consequence, his expositors, lacking Heaviside's intimate and hard-won knowledge of the vicissitudes of his operational calculus, produced books that comprise little other than stated rules of manipulation and examples illustrating use of these rules. Accordingly, even the most zealous student of these books scarcely can gain real insight to Heaviside's operational calculus; become familiar with the especial limitations, pitfalls, and other shortcomings peculiar to it; or attain marked proficiency in the accurate use of it; especially for the solution of continuous systems characterized by partial differential equations. In fact, it was realization of these facts plus a desire to establish rigorously certain useful formulas and rules of procedure advanced by Heaviside that sparked much of the early work of those who developed and advanced the other methods of operation calculus.

## THE LAPLACE TRANSFORM THEORY

Among the first to make significant advances were Wagner[61] and Bromwich,[60] the latter being characterized by Hardy[62] as "the best pure mathematician among the applied mathematicians of Cambridge, and the best applied mathematician among the pure mathematicians." Bromwich's paper (written in 1914 but delayed in publication by war) appeared in 1916, also the year of publication of Wagner's paper. Because they frequently are cited as advancing, almost simultaneously, independent rigorous proofs of Heaviside's expansion theorem, it is thought by many who have not read them that advance of such proof and illustration of its use is the main thesis of these papers and that they are much the same in content. In point of fact, though both stress use of contour integration as a means of solving boundary value problems in differential equations—a procedure which dates back to Cauchy—Bromwich's paper is much more general in character and comprises important content with which every student of the operational calculus should be intimately familiar.

The essential differences in Wagner and Bromwich's approaches have been epitomized by McLachlan.[64] The general contributions of Bromwich to the field of operational calculus have been discussed most ably by Jeffreys.[63] In particular, his remarks regarding Bromwich's work on continuous systems are of especial value.

Publication of Bromwich and Wagner's papers precedes by only a year or so Carson's[65] derivation, by classical methods, of his expansion theorem for the response of a system to impressed exponential or sinusoidal force. In subsequent work stemming from this and following papers Carson was led to formulate[67–8] an operational calculus based on his "infinite integral theorem." Though Carson recognized his integral equation as of the Laplace type, it would appear that initially he was not acquainted with solution of it by inversion through use of contour integration: ("But little work has been done on Laplace's equation from the standpoint of analysis; its most extensive and useful applications appear to be in connection with the operational calculus. Practical methods of solution are extensively discussed in the text").

In the course of validating certain of Heaviside's rules of procedure by analysis based on Volterra's theory of functionals, Levy[69] mentioned that solution of Carson's integral equation could be expressed, in well-known fashion, as a contour integral. Subsequently, March[70] pointed out that a solution so expressed was identical with Bromwich's solution. In this fashion, the two approaches of Bromwich-Wagner and Carson were merged.

In 1929, B. Van der Pol,[71] having noted Levy's suggestion, published a most important paper wherein he formulated the scheme of solution of a boundary value problem of a discrete system that is now commonly used. Multiplication of each term of the differential equation by $\epsilon^{-pt}dt$; integration between 0 and $\infty$; successive integration of each of the various integrals to obtain an equivalent expression in terms of the boundary conditions and an integral of the form $\int_0^\infty \epsilon^{-pt}f(t)dt$; algebraic solution of the resulting equation for $\int_0^\infty \epsilon^{-pt}f(t)dt$ in terms of the known boundary conditions and impressed force; and solution of this equation through use of contour integration. Van der Pol's work is complemented by that of Dalzell.[72] Additively, the latter considers solution of Poisson's equation

(the superposition equation is of this type) by contour integration. Other varieties of integral representation and contour integral solution are possible; the various restrictions and pitfalls peculiar to each have been summarized carefully by McLachlan.[73] In this same paper McLachlan stresses the advantages to be gained by equating the infinite integral to $\phi(p)/p$ rather than to $L(p) \equiv \phi(p)/p$, a point of technique often queried by the better student.

Validation of Heaviside's procedure for obtaining an asymptotic solution has been considered by numerous writers, among them Levy,[69] March,[70] Van der Pol,[71] Dalzell,[72] and Carson.[74] But the matter is a difficult one and a thorough investigation hinges on adequate knowledge of the theory of contour integration of integrands having branch points. The carefully written paper of Bourgin and Duffin[75] is recommended to the interested reader.

The Laplace transform theory of pulses, a subject not well treated in most texts, is treated in some detail in a paper by McLachlan.[76]

## JEFFREYS' OPERATIONAL METHOD

Jeffreys' operational method (*circa* 1924) is based on the use of the symbolic operator $Q \equiv \int_0^t dt$ and is founded on theory initiated by Caqué. Now convenience of manipulation and formulation of operational representations stem from introducing an auxiliary symbol $p$ defined by $(1/p) \equiv Q$. In consequence, many of the equations, operational expressions, and so forth are identical in form with those of the Heaviside calculus. This coincidence has given rise to confusion on the part of certain writers (Note the remark under $b$ in the "introduction"). It is to be emphasized, however, that in Heaviside's calculus the basic operator is $p$, defined by $p^v \equiv (d^v/dt^v)$; whereas in Jeffreys' method it is not $p$, but $(1/p) \equiv Q$ that is defined. The development of the theory can be traced in Jeffreys' monograph[12] and several complementary papers;[64,77,78] an integrated account of the present body of theory constitutes an important part of his recent book.[14]

The relative merits of the Laplace transform approach and Jeffreys' method are such that in Jeffreys' opinion:[78] "It is doubtful, indeed, whether the Mellin transform method equals the operational method in rigor or generality for discrete systems." To decide the worth of this statement, the zealous student scarcely can do better than to read the whole of the discussion underlying it.

## CONTINUOUS SYSTEMS

The operational solution of boundary value problems involving partial differential equations forms a considerable portion of Heaviside's writings. But because of the greater analytical complexity of problems involving two or more independent variables, the details of solution by Heaviside's operational calculus have proved correspondingly more difficult to justify. Bromwich and Jeffreys have done important work in this respect; and more generally they and others (especially Kryloff[79]) have endeavored to formulate a full and rigorous theory of the operational solution of continuous systems. But though well advanced, it is yet to be completed. The general difficulties attending both the Laplace transform and operational method approaches have been discussed at length by Jeffreys.[13,63,64,77,78]

In general, the treatment of continuous systems as advanced in texts on operational calculus is most unsatisfactory. Though a few give a generally adequate account of the more elementary aspects of the theory, the majority include—if anything at all—only a chapter or so; and usually this is skimpy, vague in theoretical detail, and otherwise lacking in elements essential to clear exposition. A well written book, devoted solely to an inclusive account of the present state of the operational theory of continuous systems, is greatly needed and ought to find a most cordial reception. It occurs to the writer that the preferred approach is through multiple Laplace transform theory.

## ADDENDA

Baker[80] has advanced a very general expansion theorem (including as special cases those of Heaviside, Carson, Bromwich, and others) of considerable use in practice.

Various writers have advanced kinds of operational calculus other than those cited in the foregoing. Though they have not found general use in electric circuit analysis, the author has found those of Smith[81,82] and Wiener[83] of especial interest and occasional use.

Relatively little appears to have been written in English on the use of double Laplace transform theory[84] for solving problems of electric circuit analysis involving two independent variables.

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# Xerography, a Dry Printing Process

XEROGRAPHY, a generic term for the formation of images by dry electrostatic means rather than by chemical processes, is based upon two scientific principles. The first is "photoconductivity," or the ability of certain insulating materials to become electrically conductive when acted upon by light. The other is the "triboelectric effect," or the electrical attraction of dissimilar materials in contact.

This new process is the invention of Chester F. Carlson, a New York City patent attorney, and was developed at the Battelle Memorial Institute, Columbus, Ohio. The right to use and license the process has been acquired by the Haloid Company of Rochester, N. Y., and further research is being sponsored by that company and the United States Army Signal Corps.

The plate used consists of an electrically conductive backing material coated with a photoconductive insulating material that is a nonconductor of electricity in the dark, but becomes conductive when exposed to light. The plate, when rubbed with a cloth in the dark or when sprayed with electrons in a simple device, becomes electrically charged and sensitive to light.

When exposed to an image pattern under a projection lens, a "latent electrical image" remains on the plate wherever light does not fall. The electrostatic surface charge on those areas where light strikes is discharged into the backing metal. Developing makes the latent image visible, and is done by flowing specially-prepared developing powder over the plate. The powder is made of two components, one a coarse carrier material, the other a superfine developing resin. The powder, attracted to the charged areas, clings to those portions and rolls off of the light-affected areas. The result is a mirror-reversed positive image, and corresponds to the negative in silver-emulsion photography.

Printing is done in the following manner: The image plate is prepared as in the foregoing, but the powder is not applied. The plate is placed on the rotating cylinder of a printing machine. Incorporated in the cylinder are a charging device, a mechanism for applying the developer powder to the image, a mechanism for transferring the powder image to paper, a mechanism for fixing the powder on the paper, and any cleaning devices necessary.

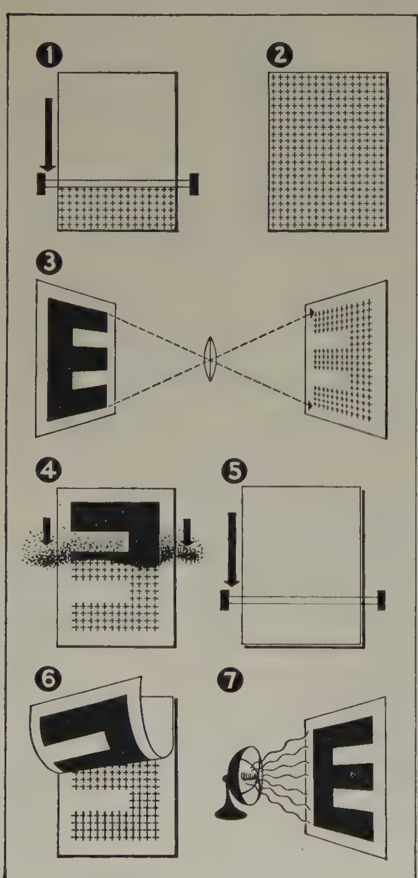

**Figure 1.**
**1. Specially coated plate is electrically charged when it passed under wires**
**2. Plate is coated with positive electricity**
**3. Projected image (E) is passed through lens and remains as positive charged image on plate. Charges disappear in areas exposed to light**
**4. Negatively charged powder adheres to positively charged areas**
**5. Paper placed over plate is given a positive charge**
**6. Direct positive image is formed on paper as positive charge attracts powder**
**7. Print is heated, fusing powder and forming permanent image**

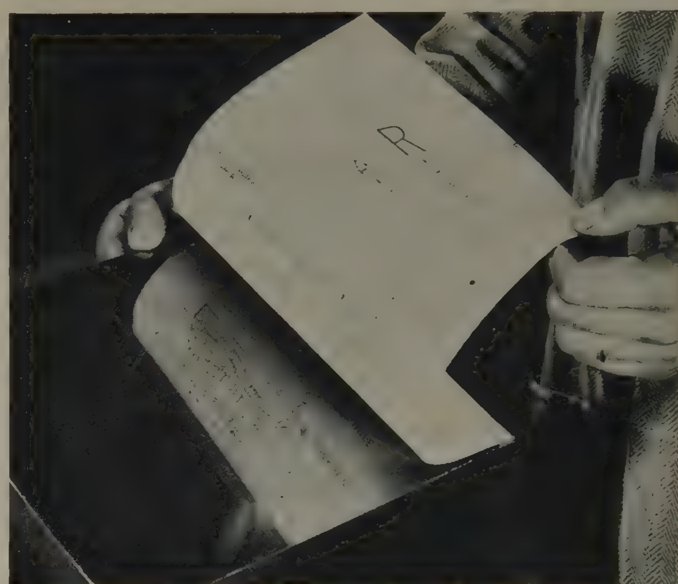

**Figure 2. Positively charged paper with the transferred print is shown being stripped from the plate. Heating to fuse powder and make image permanent will follow**

When the machine is operated, the image plate passes under a corona discharge device which imparts an electrostatic charge evenly to the plate. The charge immediately passes off the conductive surfaces but remains on the insulating surfaces. As the cylinder turns, the plate enters a developing chamber and is cascaded with the powder which remains only on the charged areas.

At the next position, the developed plate and standard-fed paper are passed together under corona discharge points where the image is transferred simultaneously to the paper and the plate is recharged. The paper, now bearing the image, is passed through a heating unit where the powder image is fixed by heat, or by use of spray.

As the process is dry, fast, simple, and cheap, it is expected to make radical changes in the publishing and printing fields.

# New Outdoor Air Switch

S. C. KILLIAN
MEMBER AIEE

THE OUTDOOR air switch is unique in that it is exposed to the elements and corrosive atmospheres for its entire life. Consequently, contacts and moving parts must give reliable service under conditions which no other equipment must face. In order to cope with these severe conditions, hundreds of ingenious mechanisms have made their appearance. These all have as their aim some auxiliary motion which breaks ice and corrosion with little effort before the main blade movement commences. This has resulted in a complicity of small levers, links, knuckles, gears, and so forth, which inherently cause trouble.

The new switch, type *MK-40*, is the result of a search for simplicity. Only three husky moving parts beside the blade are used. High-pressure contacts are used at both blade ends. No braids or flexibles are required. Current interchange surfaces are kept to a minimum. Figure 1 illustrates the switch. The blade is a one-piece hard drawn copper tube. This rotates about its own axis to release contact pressure before lifting. Heavy beryllium copper springs provide contact pressure and are independent of the hard drawn copper shoes.

By using a hard drawn copper blade and hard drawn copper contact shoes, advantage is taken not only of 100 per cent electrical conductivity but of high thermal conductivity. According to the law of Wiedemann and Franz, thermal conductivity is proportional to electrical conductivity in all metals. For fault conditions this thermal factor is very important in that heat can be rapidly conducted from the contact points.

The contact shoes carry silver inlays. This combination of rolled silver against a hard drawn copper blade was chosen after a long program of contact abrasion testing on many materials. These provide an abrasion-free contact. The switch is built from 7.5 kv to 230 kv and in capacities from 400 to 5,000 amperes.

Contact films must be given more consideration on outdoor air switches than on any other equipment. Copper and silver oxides and sulphides form readily on outdoor contacts. While all are of high resistivity at room temperature, the oxides and sulphides of silver break down readily under heat. The oxides and sulphides of copper do not. Other phenomena help puncture films however, and it is likely due to these that badly corroded contacts function at all when closed after standing open for long times. Possibly the most important of these phenomena is "coherer action." This action takes place as follows: If the film is of high resistance, free ions will migrate through the film, after which fluid metal will form exceedingly fine bridges through the film. These form at a critical "cohere voltage" which is related to the melting point of the particular contact metal as well as to the film thickness. When testing, large resistances are read on filmed contacts at low voltages; voltage is increased until the critical voltage is reached when the resistance suddenly falls to a small fraction of its original value. This phenomenon is not dependent on any combination of metals and has been shown through varnish films and on contacts actually separated by minute air distances.

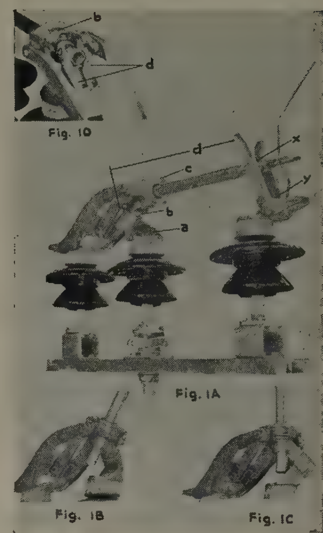


**Figure 1. New 600-ampere switch showing mechanism and contact details**

In order to check efficiency under films, a total of 66 tests was made on 600-ampere contacts such as used on the new switch. The following contact combinations were tested: copper to copper, copper to bronze, copper to silver, and silver to silver. All these had resistances of about 35 microhms when clean. Sulphide films, oxide films, and a combination of both were applied in the laboratory. Instead of testing on a voltage basis, the current was varied. Under all films, copper-copper and copper-bronze, contacts produced resistances of hundreds of thousands of microhms at one-half ampere. This resistance gradually decreased with increasing current until values of several hundred microhms were read at currents of about 400 amperes. It is interesting to note that the voltage drop across the contact remained almost constant from a few amperes to more than 200 amperes. This seems to show that the conducting filament through the film grew as the current increased. The copper-silver contact showed much lower initial resistance and also lower final resistances while the silver-silver contact had a very low resistance throughout. A silver-silver contact is not practical at the high contact pressure used. Therefore the silver-copper combination makes the next best contact, being far superior to copper-copper or copper alloys.

All tests were limited to load currents. A further program of tests on similar contacts under fault currents is planned for the near future. Much additional work remains to be done on filmed contacts and the problem will likely command more and more attention.

Digest of paper **48-248**, "A New Outdoor Air Switch and a New Concept of Contact Performance," recommended by the AIEE switchgear committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**S. C. Killian** is chief engineer for the Delta-Star Electric Company, Chicago, Ill.

# An Introduction to Ore Beneficiation

W. L. MAXSON

**Because electrical engineers have made a number of contributions to the progress of ore beneficiation, an outline of the topic is presented both as a source of general information and in an effort to stimulate interest in its future development.**

ELECTRICAL engineers, as a group, have made substantial contributions to the progress of ore beneficiation. It is therefore quite fitting that this subject should receive consideration with a view to informing the electrical engineer as to the potentialities and stimulate his interest in an active participation in its future development.

The winning of metals from nature's storehouse involves several steps—some of which are specific to the particular metal to be produced—although in general there are major operations common to practically all treatment processes.

The major steps may be divided, roughly, into mining and beneficiation (which may include smelting and refining) together with the necessary handling and transportation phases.

Electric energy is practically always a necessary component of all these operations. Its effective and economical utilization is of great importance, although the degree to which it is used always is limited by the cost of power and the amount required—measured against the dollar value of the metal to be produced. For example: electric furnaces are used with economy in the production of aluminum, certain ferro-alloys, and high value alloy steels. But in the case of pig iron, the reduction by coke is generally more economical.

In approaching the subject of ore beneficiation, it seems pertinent to analyze the word. In its broadest sense it comprehends the treatment of ores to improve their quality, which in turn normally is accomplished by separating undesirable material, and preparing the product for the next step toward the ultimate goal, which is the production of metal, or one of its compounds.

The waste materials may be separated by application of heat, under oxidizing or reducing conditions, by dissolving and precipitation (electrically or otherwise), and by a great variety of machine applications. This article is concerned largely with the last group.

Ore beneficiation processes usually include as a primary step the reduction in size of the coarse material as it comes from the mines. This is accomplished by crushing, and usually is followed by other stages of crushing and grinding until the original material has been subdivided to such a size that the desired minerals are relatively free from attached pieces of waste. The material is then ready for the separation step.

The size of the product at this point may be extremely fine, possibly all passing 74 microns, and the difficulty of separating usually increases with the fineness.

The separation processes are developed to take advantage of the specific properties of the mineral to be won. These may include physical, chemical, electrical, and combinations thereof. For example, copper is produced very largely from sulphide minerals, which can be separated from waste by levitation on bubble surfaces. A mixture of finely ground ore and water is agitated with specific chemicals and oils which are added to secure selective adherence of the sulphides to air bubbles, which lift them to the surface against the force of gravity. The sulphides are removed as a froth, and this process is called froth flotation.

Some oxide minerals may be separated by the same process. The magnetic iron ores readily are separated into concentrates and waste by bringing a mixture of solids and water into an electrical field which attracts the magnetic fractions. Some ores can be changed by reducing gases to alter basic characteristics and thus permit magnetic separation. Where reasonable differences in specific gravity exist, the force of gravity may be used effectively. Controlled suspensions may be used to develop a heavy liquid which will reject lighter components of an ore as a floating mass. The heavier part sinks by gravity to effect the separation. Centrifugal force has been used to some degree, and may be more important in the future.

When dealing with small hourly tonnages dry separation processes often can be used, as in electrostatic separation.

By and large the mining industry is concerned with substantial tonnages which require cheap handling of large bulk volumes of solids. This implies the economical distribution and control of large blocks of electric power. But as large as these present-day installations are, the future demands promise to be much greater. The major development on the horizon will be the beneficiation of large tonnages of hard, compact, iron bearing rock in the Upper Lakes region—to provide the essential raw material for the steel industry in the form of concentrated iron minerals. This will require that from two to three times as much tonnage be mined, and beneficiated, as that now required for the same pig iron production.

The question properly arises: Why not ship the raw material without beneficiation? The obvious answer is based upon the economics for the particular case. Broadly speaking, the iron blast furnace is a beneficiation machine in that it eliminates waste material as a molten slag. The waste material in the original ore can be eliminated at a

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**W. L. Maxson** is with the Oliver Iron Mining Company, Duluth, Minn.

cost in the blast furnace, but the over-all economics demonstrate that some proportion of waste should be removed near the mine, thus reducing the bulk of material to be shipped, and at the same time, reducing the amount of coke and limestone required at the blast furnace. The economic cost balance will determine the relative proportions to be removed in each step. The basic characteristics of the specific deposit also will place a limit on the amount which can be removed effectively at the mine, at a minimum cost.

Beneficiation on the Minnesota iron ranges is not new. It was inaugurated 40 years ago by the United States Steel Corporation in a pilot plant, which was replaced by a large commercial installation in 1910, and which is still in operation. Many other plants were built by the industry, and a substantial annual tonnage continues to flow from this source. This tonnage is expanding in volume and will continue for many years in the future.

The treatment methods have been simple, because the iron minerals were relatively free as mined, and coarse enough to be separated effectively by gravity.

By contrast, the winning of iron minerals from the low grade iron formation will be more complex, because the mineral crystals are much finer in size.

Fine grinding will be required—and the separated product will have to be dewatered, dried, and agglomerated to make it suitable for the blast furnace.

The leaders of the industry are, and always have been, keenly aware of their duty to protect their sources of raw materials, and in looking ahead to this end, joint research by the leading producers was started some time ago. Individual research groups also have been provided with all modern facilities to pioneer methods to insure a continuous production of this essential raw material for the blast furnaces. Pilot plants are already in operation, and large scale production units will follow in due course.

As this new phase expands, the Upper Lakes region will assume its place as one of the major beneficiation centers of the world.

Several types of processes will be used, but in any case, large increases in power requirements are indicated. The industry will welcome the contribution which electrical engineers will make to the ultimate success of this important development.

# Electric Power in a Large Iron Ore Beneficiation Plant

A. F. GETTELMAN

**Large iron ore beneficiation plants introduce new problems of distribution and utilization of electric power in the iron mining industry. The selection of voltage levels for generation and main distribution, large and small motors, is based on a study of installed cost system reliability and efficiency. A modern load center system of distribution of a-c and d-c power for a large plant unit is demonstrated.**

RESERVES of high grade iron ore in the United States are running out; some experts estimate that direct shipping ores of 50-65 per cent iron content will last only another eight to ten years. Of course, some ore requirements have been and will continue to be supplied from intermediate ore concentrated in plants using a simple sedimentation process of washing, classifying, and crushing when necessary. However, the low grade taconite ores of the Mesabi range must be concentrated or beneficiated in increasing amounts if we are to maintain our steel production from domestic sources.

Taconite ore occurs in both magnetic and nonmagnetic forms. The taconite to be beneficiated in the plants now being planned is a hard dense rock averaging about 24 per cent iron in the form of magnetite. The iron content is so finely divided that nearly all particles are smaller than 20 mesh. The rock must be crushed in three or four stages and then be ground to a powder so fine that 85 per cent of it is minus 320 mesh. Magnetic separators reduce the burden of grinding in the ball and rod mills and in combination with classifiers and a plentiful supply of water produce a concentrate in the form of a fine black powder which must be sintered or made into hard pellets to be suitable for the blast furnaces. Nearly three tons of iron bearing rock is reduced to one ton concentrate of approximately 64.5 per cent iron.

To utilize the low grade ore, huge beneficiation plants must be built—plants that will require 25,000-30,000 installed horsepower to produce 2,500,000 tons of concentrate annually. This article discusses the problems of electric power distribution and utilization in such plants as these.

Full text of paper **48-313**, "Power Distribution and Utilization in a Large Iron Ore Beneficiation Plant," recommended by the AIEE mining and metal industry committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**A. F. Gettelman** is with the General Electric Company, Minneapolis, Minn.

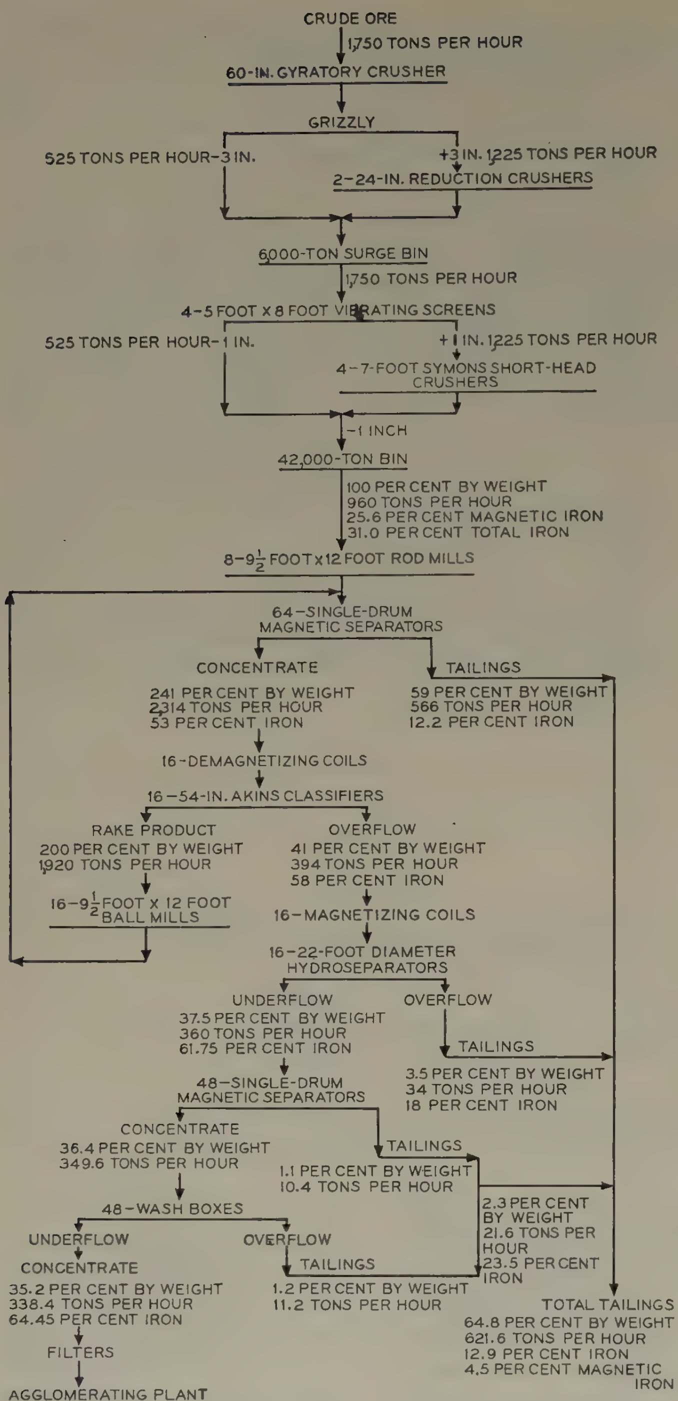



**Figure 1. Flow sheet for a typical large beneficiation plant unit**

The importance of the subject can be appreciated when it is considered that 60-75 kilowatt hours will be required to produce one ton of concentrate from taconite ore. In 1935 the Minnesota ranges produced a ton of iron ore with 3.5 kilowatt hours of electric power. To produce 2,500,000 tons of concentrate may require as many kilowatt-hours as was used to produce 63,000,000 tons of ore in 1945.

While experimental plants of about 200,000 tons annual capacity are being built, the ultimate plants for economical operation must be much larger units. Plans are now under consideration for a beneficiation plant unit with a capacity of 2,500,000 tons of concentrate annually, with ultimate expansion to four units producing 10 million tons. The flow sheet for such a plant unit is shown in Figure 1, and the power requirements are listed in Table I. The approximate connected horsepower for such a plant unit is

Crushing plant—3,500 horsepower
Concentrating plant—18,000 horsepower
Sintering plant—8,000 horsepower

Power for beneficiation plant units with 30,000 connected horsepower is not available at present in the areas of the Mesabi range containing the ore reserves. Generating plants will have to be built near the plant site where conditions are favorable, and the following is based on the typical beneficiation plant with power generation at the plant site. In addition, it also is assumed that the single unit plant will be built and operated as a single unit for some period of time.

## SELECTION OF SYSTEM VOLTAGE LEVELS

The following table shows the utilization equipment voltage ratings, generator and stepdown transformer voltage ratings, and the corresponding nominal system voltages with which we are concerned in a beneficiation plant such as this:

| Utilization Equipment Voltage Rating | Generator Transformer No-Load Voltage Rating | Nominal System Voltage Class |
|---|---|---|
| 440 or 460 | 480 | 460 |
| 2,300 | 2,400 | 2,400 |
| 4,000 | 4,160 | 4,160 |
| 13,200 | 13,200 to 14,400 | 13,800 |

The selection of the proper system voltage for the first plant unit and for future plant units should be on the basis of over-all economy. The cost of component parts of the power system including switching equipment, distribution channels, transformers, and even the rating of motors must be taken into consideration.

The chart in Figure 2 shows the selection of the main generation and distribution level for new plants based on good engineering practice. For a plant with 30,000 horsepower installed and generation at the plant site, 13,800 volts is the preferred level for the main generation and distribution.

## SELECTION OF MOTOR VOLTAGES

The horsepower ratings of motors in a modern beneficiation plant range from one-horsepower induction motors

**Table I. Power Requirements for a Beneficiation Plant Unit of 2,50,0000 Tons Annual Capacity**

| | | Kw-hr Per Ton of Sinter |
|---|---|---|
| Mine | | 2.32 |
| Concentrator | | |
| Crushing | 4.51 | |
| Primary grinding | 7.47 | |
| Secondary grinding and cobbing | 26.35 | |
| Magnetic concentration | 3.24 | |
| Filtering | 1.19 | |
| Water supply | 5.06 | 47.82 |
| Sinter plant | | 20.63 |
| Miscellaneous facilities | | 0.80 |
| Total | | 71.57 |

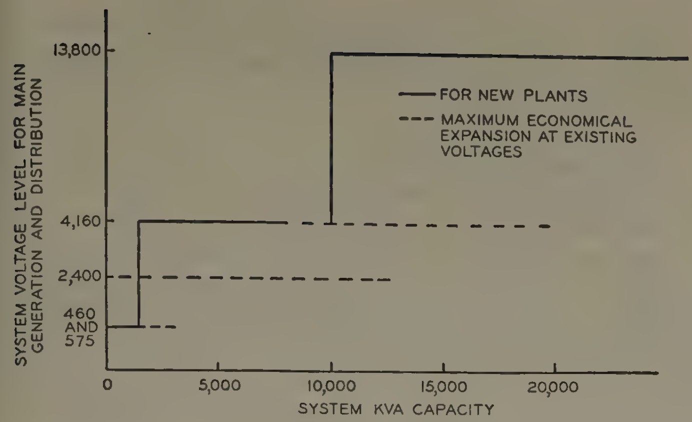



**Figure 2. Chart showing selection of main generation and distribution voltage in terms of mill electrical capacity**

on feeders and separators to large synchronous motors on rod and ball mills, and also on fans for a sintering plant. Plans available today on these plants do not indicate the use of motors over 1,000 horsepower.

Motors with 440-volt rating have been standard in the mining industry for the lower horsepower range, and will be used in the beneficiation plants. Many studies have shown that a 220–230-volt rating would not be economical due to the increased cost of feeders, control, and switching equipment. Motors of 550-volt rating have been used in other industries such as some paper or textile mills, but new plants are using 440-volt motors due to their greater availability.

In the higher horsepower range up to 1,000 horsepower, 2,300-volt or 4,000-volt motors will be used. To determine what part of the horsepower range will use 440-volt motors, the over-all economy must be considered, taking into account the costs of motors and their controls and transformer capacity, since all motors will require installed transformer capacity with a main distribution voltage of 13,800 volts.

Transformer costs in dollars per kilovolt-ampere decrease as the transformer rating increases. However, as the transformer rating increases the fault duty in the low-voltage bus increases, requiring larger and more costly circuit breakers.

For the 440-volt motors, the optimum size of unit substations ranges from 500 to 1,500 kva. Where load concentrations are high, as in the concentration plant, studies indicate the use of 1,000-kva units.

For the 2,300-volt or 4,000-volt motors in the higher horsepower range, larger transformers units are warranted, since short-circuit interrupting levels up to 150,000 kva at 2,400 volts, and 250,000 kva at 4,160 volts may be used with good economy. For the 2,300 or 4,000-volt motors, unit substation transformers of 5,000 or 7,500 kva respectively will provide the best over-all economy, taking into account location of load, circuit arrangement, and so forth. In the circuit arrangement as shown in Figure 4, the use of 6,000-kva transformer units is indicated.

To compare the costs of motors and controls, the curves in Figure 3 have been drawn, based on standard 1,200-rpm induction motors and full voltage starting. At 200 horsepower a comparison of the 440-volt and the 2,300-volt motor and control shows an increased cost of approximately four dollars per horsepower at 2,300 volts. However, the investment cost in transformer substation capacity for the 2,300-volt motor will be from four to six dollars less, depending on the load factor used. From this comparison it is apparent that motors up to about 200 horsepower can be served more economically at 440 volts. Figure 3 does not show the comparison of synchronous motors and controls. However, there is less price differential between 440-volt and 2,300-volt synchronous motors and control than there is between induction motors and control at these voltages. The result will be to bring the curves closer together in Figure 3 and lower the maximum horsepower rating to be used at 440 volts.

Based on this division of motor voltage ratings, the power requirements for the plant are divided approximately as follows:

*A—Crushing Plant:*

1. Induction motors over 200 horsepower for driving crushers and large conveyor belts.
2. Induction motors under 200 horsepower for driving conveyor belts, feeders, screens, and dust collectors.
3. Miscellaneous power for lighting, crane repair shops, and so forth.

*B—Concentrating Plant:*

1. Synchronous motors over 200 horsepower for driving ball mills and rod mills.
2. Induction motors over 200 horsepower for driving pumps.
3. Induction motors under 200 horsepower for driving conveyors, classifiers, magnetic separators, pumps, and so forth.
4. D-c power for

(*a*). Excitation of magnetic separators.
(*b*). Excitation of magnetizing coils.
(*c*). Excitation of synchronous motors.
(*d*). D-c motors driving adjustable speed feeders to the grinding mill.

5. Miscellaneous power including lighting repair shops, cranes, demagnetizing coils, and so forth.

## POWER CIRCUIT FOR SYNCHRONOUS MOTORS ON ROD AND BALL MILLS

The rod and ball mills (Figure 1 flow sheet) will be driven by slow-speed synchronous motors in horsepower ratings between 450 and 700, using full voltage starting, as is the practice in ore treating mills now in operation. The voltage rating of these motors can be 2,300 or 4,000. A study must be made of all factors, including cost of switching equipment, motors, controls, and feeders to determine the most economical voltage rating of these motors.

A mill unit with 24 synchronous motors of 500 to 700 horsepower will require a number of small transformers and a multiplicity of switching equipment if a selective bus arrangement is used and the motor circuits are to be limited to a low interrupting level for short-circuit duty. With a low interrupting level, a large voltage drop occurs when starting a large synchronous motor. Since motor torque is proportional to the square of the voltage, it therefore is reduced considerably. The high torques required for synchronous motors used on ball and rod mills represent a substantial part of the first cost of these motors. For example, if the interrupting level and short circuit is limited

to 25,000 kva, then a 600-horsepower motor with 600 per cent locked rotor current and power factor of 40 per cent would have only $86^1/_2$ per cent voltage on starting, and this will produce only 75 per cent of the full voltage starting torque on the motor.

Full voltage starting, using electrically operated power oil circuit breakers in metalclad switchgear, has been the practice on the ball and rod mill synchronous motors. With the development of the modern high-voltage air circuit breakers of the magne-blast type, the use of oil circuit breakers can be eliminated. The air circuit breakers will reduce contact maintenance when used in the motor starting units.

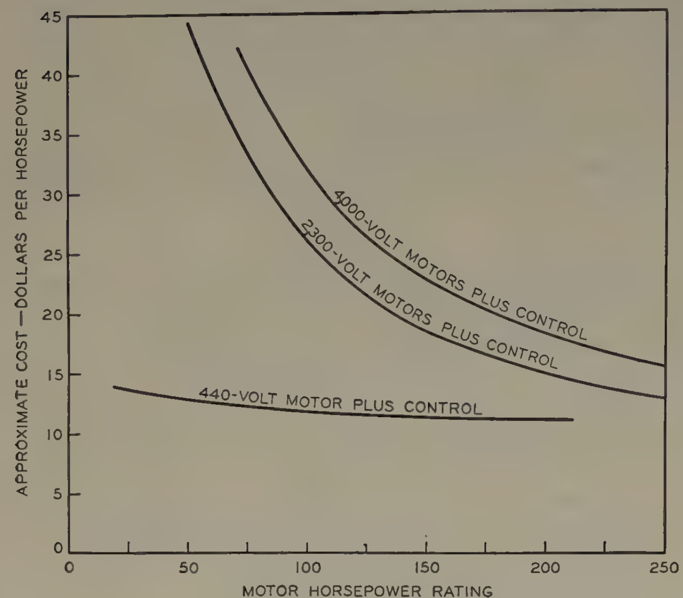



**Figure 3. Cost of motors and control versus horsepower rating of motors**

Another type of motor starting control that has found widespread use in other industries, such as the rubber and paper mills, is one utilizing modern high-voltage air break contactors with short-circuit protection provided by means of high interrupting capacity current-limiting fuses. These air break contactors have been used on severe operating cycles and are suited particularly for jogging operations where a mill is being rotated to a given position.

The current-limiting power fuses are coordinated with the motor so that they will operate only under short-circuit conditions and will not blow unnecessarily on motor starting and stalled rotor currents. The current limiting action of the fuse reduces the fault damage by limiting the fault current.

The maximum economical ratings for power circuit breaker are

| Circuit Breaker Ampere Rating | Interrupting Rating Kva |
|---|---|
| | 2,400-volt service |
| 600 | 100,000 |
| 1,200 | 150,000 |
| | 4,160-volt service |
| 600 | 150,000 |
| 1,200 | 250,000 |

High interrupting capacity motor starters with current-limiting fuses, also follow the same limits as circuit breakers, that is, system fault duties of 150,000 kva at 2400 volts and 250,000 kva at 4,160 volts.

From the foregoing table it will be noted that a 600-ampere circuit breaker is adeqate to interrupt 150,000 kva at 4,160 volts, whereas a 1,200-ampere circuit breaker is required to interrupt 150,000 kva at 2,400 volts. The power circuit breaker not only must be capable of interrupting the fault current at the time of short circuit, but also must withstand the high mechanical forces produced by the initial first half cycle of short-circuit current. There is also a limit to the current a power circuit breaker will interrupt regardless of voltage, and it also may not be able to interrupt its rated kilovolt-amperes at all voltages.

At 4,160 volts, the power circuit breakers and current-limiting fuses may be applied up to their maximum interrupting rating. A 600-ampere power circuit breaker at 4,160 volts will carry 1.73 times the kilovolt-amperes that it will at 2,400 voots. The installed cost of cable is approximately inversely proportional to the system voltage or 73 per cent more for the 2,400-volt system than for the 4,160-volt system.

Figure 4 shows a proposed power distribution system for a modern beneficiation plant using a flow sheet similar to Figure 1. A modern load center system of power distribution is used for the power requirements for both the high-voltage mill motors and also the low-voltage motors.

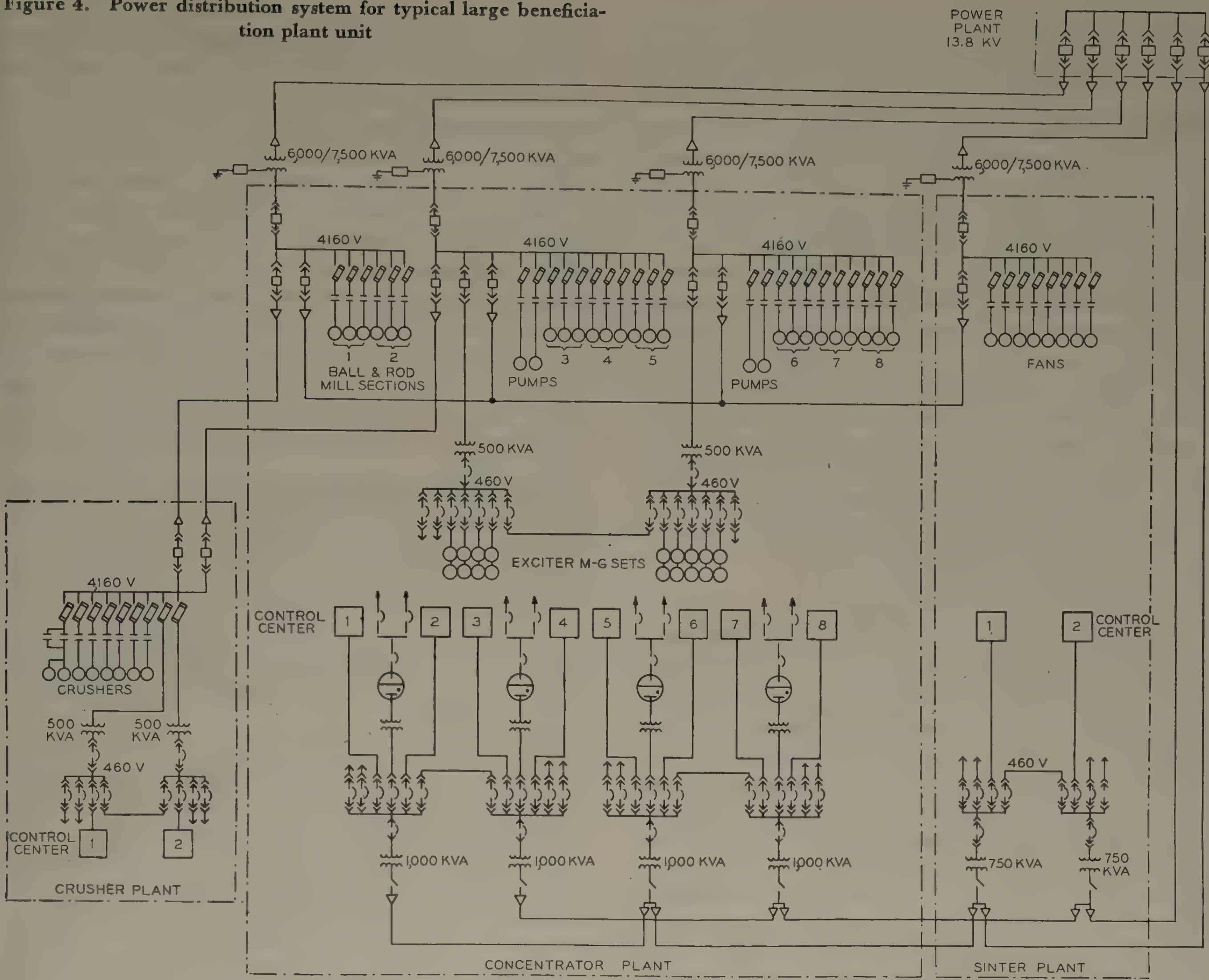
The synchronous motors on the ball and rod mills have a 4,000-volt rating. Power is supplied to these motors from master unit substations with 3-phase oil-filled transformers equipped with fans for increased supplementary rating. Each unit substation transformer has a cable junction entrance for the 13.8-kv cable from the generating plant. Oil-filled transformers are indicated as the concentrator plant construction usually will permit the transformers to be located along the outside wall of the building at locations convenient to the motor loads they serve.

Where the control room can be located along the outer wall of the concentrator plant, convenient to the transformers, a metal-enclosed bus duct is a preferred means of connecting the transformer to the metalclad switchgear. This arrangement provides a completely enclosed system from the power station to the motor. The space requirement is much less than for the older type substations using single-phase transformer banks and open bus work and disconnect switches. A high degree of saftey and reliability is obtained, and switching is accomplished safely and quickly with circuit breakers of full interrupting capacity.

Normally, the substations would be operated separately. With the tie bus as shown, in the event of a transformer or a feeder failure, the bus sections can be operated from the remaining three substations in parallel without exceeding the circuit breaker or fuse interrupting rating. The 13.8/-4.16-kv master unit substations consist of a transformer, metalclad switchgear which contains the tie and feeder circuit breakers, and the motor control sections using current-limiting fuse starters.

To permit using the full 250,000-kva interrupting rating of the power circuit breakers and current-limiting fuses in

**Figure 4. Power distribution system for typical large beneficiation plant unit**




the motor controls when the tie circuits are closed, 4,160 volts was selected. To use 2,300-volt motors in a circuit as in Figure 4, the short-circuit interrupting level must be limited to 150,000 kva, and will require the use of current-limiting reactor units in each of the tie circuits. A study of comparative costs shows that the savings at 2,400 volts in costs of motors and control is offset by the additional cost of the feeders, power circuit breakers, and reactor units in the switchgear.

The use of motor controls with current-limiting fuses of high interrupting capacity represents a considerably lower investment than motor controls using power circuit breakers at the high interrupting levels.

In choosing a circuit arrangement such as that shown in Figure 4, a balance between the desired reliability and the installed cost of the system must be considered. With the large capital investment in the plant and with 3-shift operation of the concentrator plant, continuous power supply is essential.

## GROUNDING OF HIGH-VOLTAGE MILL CIRCUITS

The established practice has been to operate the present mills with the 2,400-volt motor circuits ungrounded; the thought being that with the system left ungrounded no loads would be lost and the system operated until some future time when the ground could be removed.

Aside from having to isolate each circuit to find the ground, there are other disadvantages of an ungrounded system. The occurrence of a ground on one phase overstresses the windings of all machines while the ground is on. Switching surges and arcing grounds can produce serious overvoltages up to six times normal. As a result, flashovers that are difficult to explain are found at locations remote from the actual ground fault.

In Figure 4, the neutral of the y-connected 4,160-volt winding on each 13,800/4,160-volt substation unit is grounded through a current-limiting resistor. This resistor can be mounted in a protective metal enclosure on the transformer unit itself. Ground fault relaying is provided on all feeder circuits, and phase protection on the motor starters.

## D-C EXCITATION OF SYNCHRONOUS MOTORS

The use of separate motor-generator sets rather than direct-connected or V-belt-connected exciters saves valuable space in the mill area. The motor-generator sets can be located under better operating conditions in the control room. If an individual motor-generator set is furnished

for each motor, a large number of small units are required. If, on the other hand, several large motor-generator sets are used for excitation of all the synchronous motors, spare capacity and d-c distribution are important factors. The a-c motors on the motor-generator sets can be supplied best from the 4,160-volt mill motor circuits to provide the desired reliability.

In the arrangement as shown in Figure 4, a motor-generator set exciter is provided for each of the mill sections. Each mill section consists of two synchronous motors driving ball mills and one synchronous motor driving a rod mill. A spare set can be connected to any section and provides reliability with a minimum of equipment.

The exciter sets are supplied from two 4,160/480 load center units using noninflammable liquid-cooled transformers. Control for the exciter set motors may be incorporated conveniently in the secondary switching section of the load center unit. Additional 460-volt power for lighting, control battery charging, and for small feeder motors on this side of the mill also can be taken from these unit substations.

### POWER CIRCUITS FOR LOW-VOLTAGE MOTORS

Load center unit substations using askarel-filled transformers are available for 13.8-kv circuits and will provide the most satisfactory and economical distribution of 460-volt power. They can be located in the control room adjacent to the 440-volt motor load. With magnetic ore dust and moisture present, the use of air-cooled transformers would require special attention. Studies that have been made indicate that for the 460-volt concentrator power, units of 1,000-kva capacity will be the most economical. The use of two 13.8-kv feeders with several unit substations on each feeder and a secondary selective system is preferable to a primary selective system which would require 13.8-kv switching equipment.

The concentration of 440-volt motors in the mill is such as to provide an excellent application of modern control centers, incorporating the short-circuit and thermal overload protection in each starter for the individual motors. With control centers located in the control room apart from the classifiers and pumps, the control equipment can be maintained more satisfactorily, with greater accessability and with space saved in the mill.

### MAGNETIC SEPARATORS

From the flow sheet (Figure 1) it will be noted that 64 single drum "roughing" magnetic separators are used after the rod mills and 48 single drum "finishing" magnetic separators are used after the hydro separators. Typical power requirements for the magnets are as follows:

| | Pick-Up Pair Numbers 1 and 2 | Tailings Pair Numbers 3 and 4 | Concentrate Pair Numbers 5 and 6 |
|---|---|---|---|
| 48-in. drum rougher separator | 3.3 kw max | 4.0 kw max Operate at 2.8 kw | 4.0 kw max Operate at 2.8 kw |
| 48-in. drum finisher separator | 3.3 kw max | 4.0 kw max Operate at 3.1 kw | 4.0 kw max Operate at 3.1 kw |

Based on the foregoing requirements, 64 roughing and 48 finishing magnetic separators would require approximately 1,000 kw of d-c power for magnetic excitation. While the use of 125 volts direct current may be preferred in the winding of the magnetic separator coils, 230-volt d-c separators are standard and there is comparatively little difference in price. Therefore, a 250-volt d-c supply system is recommended as it will provide the lowest cost distribution system including cables, switches, and power supply equipment.

If the magnetic separators can be wound for the approximate field strength required in actual operation, then very little power loss occurs in the rheostats on the tailings and concentrate magnets where adjustment of operating strength is required. On this basis, the most economical power supply is a 250-volt d-c rectifier of the sealed tube ignitron type.

Where a wide range of magnet strength may be required and the operating losses in the rheostats of the magnetic separator are considerable, the use of multiunit motor-generator sets with separate excitation should be considered for over-all economy. The magnetic separators in any one of the eight mill sections would be adjusted as a unit, and the same voltage impressed on all tailings or concentrate coils in a roughing or finishing section from an adjustable-voltage generator.

The driving motors for the motor-generator sets will be of sufficient size so that they can be operated directly from the mill circuits which supply the synchronous motors on the ball and rod mills. Since there will be available with the high torque synchronous motors on the rod and ball mills an excess of leading reactive kilovolt-amperes, synchronous motors are not essential on these motor-generator sets.

The sealed tube ignitron rectifier will consist of a transformer section, a rectifier section, and a d-c distribution section. The primary low-voltage air circuit breaker will be located in the unit substation supplying power to the rectifier. These rectifiers could be supplied from either the 13.8-kv circuits, 4,160 volt, or the 480-volt circuit. An over-all study of the cost of feeders, switching equipment, and transformer capacity must be made in each case to determine the most economical installation. In Figure 4, four 300-kw sealed tube ingitron rectifiers are shown. Each rectifier unit furnishes the d-c power requirements for two of the eight mill sections. The rectifiers are operated from the 480-volt unit substations which are located along side the rectifiers in the same control room.

The d-c distribution section in each rectifier will provide the protective circuit breakers for supplying two sections of magnetic separators. These circuit breakers should be of the type used for field circuits of large a-c generators and should have a discharge contact for the highly inductive magnetic separator coils. They also can be electrically operated for remote control from the operating floor. Ground detector lamps on the panels will be provided for indicating grounds in the magnet coils.

### CRUSHING PLANT POWER DISTRIBUTION

The location of the crushing plant is a factor in the selec-

tion of the circuit arrangement to be used. In Figure 4, it is assumed that the entire crushing plant is located adjacent to the mill.

The power supply to the crushing plant must have the same degree of reliability as for the concentrator plant. In Figure 4, the crushing plant power is supplied at 4,160 volts from one of the 3-phase unit substation transformers. The large crusher motors are supplied directly at 4,160 volts and the smaller motors below 200 horsepower are supplied at 460 volts from a load center unit substation.

When a central crushing plant first is built, with capacity for several mill units, then the power requirements and the load locations may be such that a 13.8-kv circuit to the crushing plant is more desirable.

### MOTORS AND CONTROL FOR CRUSHING PLANT

High-voltage air break contactors have been designed for severe duty cycles such as in mine hoist service and will require a minimum of maintenance in the operation of large crusher motors where frequent starting and stopping and reversing is encountered. In the past, electrically operated oil circuit breakers have been used for this service. However, under frequent operations, the maintenance of latching mechanisms and circuit breaker contacts is a considerable item.

The large gyratory crushers such as the 60-inch size will require two motors of the wound rotor type, each motor driving the main gear on the crusher through its own pinion. The two motor stator windings can be connected in parallel to one set of reversing air break contactors. Four-pole secondary contactors will provide separate balanced accelerating steps for the rotor circuits of the two motors. Definite time limit acceleration is provided by means of magnetic time delay relays.

Gyratory crushers of the 24-inch size also will be driven by wound rotor motors and will use a control similar to that for the 60-inch crusher except designed for a single motor. The short head crushers usually are driven by squirrel cage induction motors. Full voltage starters using air break contactors are shown for these motors.

All control units with air break contactors will be protected by current-limiting fuses of 250,000-kva interrupting capacity at 4,160 volts.

### CONVEYOR BELTS

A large number of conveyor belts of varying width, length, speeds, and lift are required to transport the ore through the various stages of crushing, grinding, and concentrating. For the smaller belts, requiring 100 horsepower or less to drive, excellent results have been obtained with high torque squirrel-cage induction motors and full voltage starting. The high starting torque motors such as type *KG*, have approximately 200 per cent starting and 200 per cent pull-out torque which is usually ample for starting the belt under all operating conditions. The use of normal torque motors often results in overmotoring the drive with resulting higher belt stresses.

Conveyors requiring motors of 200-300 horsepower usually are equipped with belts operating under high stresses. To limit the starting and accelerating torque on these belts, wound rotor motors with secondary control providing automatic time limit acceleration are recommended.

On extremely large belts operating at high stresses, where starting and accelerating torques must be held to a minimum, a large number of accelerating contactors would be required. A number of installations are now in successful operation using a standard 13-point motor-driven drum controller to provide definite time limit acceleration in place of the contactors. A magnetic time relay provides a means of adjusting the time interval between the first several accelerating points. Control circuit cams on the drum controller provide for sequence starting of the next unit, or sequence starting between two motors operating in tandem on the same belt, and for the release of hold-back devices that may be used. The controller is interlocked with the primary starting switch so as to start only when on the first controller point.

### AGGLOMERATING PLANT

To complete the picture of the beneficiation plant, a brief review is in order, of the two methods of agglomerating the concentrate, namely, sintering and pelletizing.

*Sinter Plant.* In the sintering process, the powdered concentrate is mixed with 4–6 per cent pulverized coke or coal, and the mixture distributed on a long slow moving chain grate. The mixture is ignited and combustion is maintained by large induced draft fans connected to suction boxes under the grate. After leaving the grate, a water quench produces a suitable furnace product in the form of clinker.

The power supply for a sintering plant has been included in Figure 4. Large synchronous motors on the fans constitute the major part of the load. In the proposed plan for one large plant, these motors are rated 900 horsepower. The motors must be 4,000 volts in ratings above 700-horsepower, 0.8 power factor for full voltage starters using current-limiting fuses.

The 460-volt load center power distribution system is similar to that shown for the concentrator plant.

The use of a tie circuit also on the 4,160-volt sinter plant thus provides power for the sinter plant on loss of a feeder or transformer unit. Three transformer units may be operated in parallel if necessary for carrying the entire load without exceeding the 250,000-kva interrupting level.

*Pelletizing Plant.* Experimental work is being carried on and pilot plants are being built to produce in commercial quantities, a furnace product from the powdered concentrate by means of the pelletizing process developed in the Minnesota mines experiment station. This process holds great promise of reducing the cost over that now obtained in ore concentrating plants using the sintering process.

The pelletizing process consists of mixing 1.25–1.5 per cent finely pulverized coal with the powdered concentrate along with the proper moisture and balling up this mixture in a revolving drum. The wet balls, $^1/_2$ inch to $1^1/_4$ inch in size, then are charged in a vertical shaft furnace where the temperature is maintained slightly under the fusion point of the concentrate.

No complete data are as yet available on the power requirements for large pelletizing plant units. From available data it appears that the maximum motor horsepower ratings will be within the limits of 460-volt distribution. On this basis, the power distribution would consist of load center unit substations 13,800/480 volts with a primary arrangement and secondary selective system as in Figure 4, for the 460-volt power distribution in the concentrator plant.

### LIGHTING DISTRIBUTION

A combined lighting and power system will provide low first cost and excellent over-all service reliability in the plant areas. In this system, small dry-type transformers are connected to 460-volt feeders on the load center unit substations to provide the lighting power requirements. The use of separate transformer substations and feeders for lighting, especially in buildings such as the concentrator which may exceed 600 feet in length, would result in considerably higher first cost and less service reliability.

In areas remote from the mill where lighting and small motor loads are encountered, such as large offices and mill laboratories, 208Y/120-volt service is advantageous since both single-phase and 3-phase power is available for both lighting and small motors.

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# Radio-Frequency Mass Spectrometer

The exacting requirements of detecting, separating, identifying, and measuring negative atomic ions of the heavier metallic elements now have been met by means of a specially designed vacuum tube which provides a simplified and flexible radio-frequency mass spectrometer. Experiments begun in 1946 at the National Bureau of Standards by Doctor Willard H. Bennett indicated that these negative atomic ions might exist in the many familiar forms of electrical discharge in vacuum tubes, but that they would not be detected if the distance through the tube between the discharge and the electrode was large. It was necessary to devise an experimental method for separating and identifying such ions within distances of only a few centimeters. This was accomplished by means of the new mass spectrometer tube.

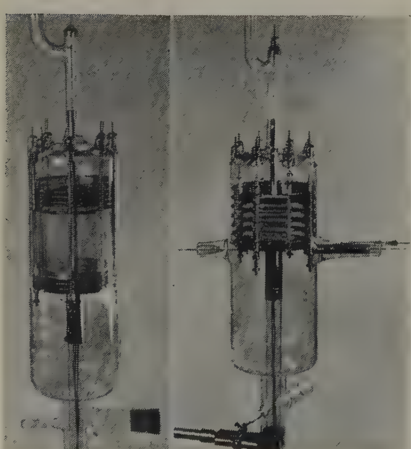

**Figure 1 (left). The 2-stage 9-electrode radio-frequency mass spectrometer, and (right) the special negative-ion research tube modification of it. These are essentially multigrid tubes with an adjustable radio frequency applied to two grids, with all other electrodes held at proper d-c potentials, and ion current is measured at the anode**

In a more advanced form, this 2-stage spectrometer may be used for positive ions as well as negative ones. The equipment consists essentially of a multigrid tube in which an adjustable radio-frequency voltage is applied to two grids of the tube, while all other electrodes are held at the proper d-c potentials, and the ion current is measured at the plate. Because large electromagnets or tubes containing electrodes with elaborate slit systems are not required, this spectrometer will find use where its resolution is sufficient and where the expense of more elaborate beam-deflection equipment is not justified.

One of the principal limitations upon the resolution possible with ordinary magnetic beam-deflection mass spectrometers has been the spread in energies of the ions at the ion source. In the radio-frequency mass spectrometer, this difficulty is eliminated, and the voltage of the ions easily can be pushed up at least an additional order of magnitude to any value for which insulation can be provided. The frequencies required then are increased by an amount equal to the square root of the factor by which the voltage is increased.

The first successful model, a single-stage 6-electrode tube, consists of a cathode about which are arranged four coaxial cylindrical grids and an ion-collecting plate. Helmholtz coils surrounding the tube provide a 100-gauss magnetic field in a direction parallel with the axis of the tube. Such a field is required in negative-ion work to confine the electrons to the space inside the first grid and to avoid the formation of positive ions in parts of the tube where neutralization of the negative ions may occur before they reach the detecting electrode.

By extending the method to two stages in a 9-electrode tube, and applying the radio-frequency to two of the grids, a high order of mass resolution is obtained. Such a large number of grids is made possible through use of a knitted wire fabric screen with 95 per cent open area, rather than the usual woven-wire type. Simplicity and low cost of the spectrometer will make it available to research groups for several specialized applications.

# Voltage Control Without Feeder Regulators

N. N. SMELOFF
ASSOCIATE AIEE

PROMOTION of the use of electric energy requires that the voltage supplied to the user be of a level and a character that will not have objectionable effects upon the utilization equipment. The level supplied must be neither too high nor too low, and the variation must not be noticeable. On the other hand, it is not economically sound to furnish a voltage that is better than necessary to meet these requirements. The over-all objective, then, is to supply enough capacity for adequate voltage control at a minimum over-all cost.

Pennsylvania Power and Light Company has met this objective with a very limited use of feeder voltage regulators. In a manner analogous to the regulation of several feeders from a bus whose voltage is controlled by a single regulator, the voltage level of the entire supply system is raised and lowered with the corresponding variations in load to compensate for the variations in voltage drop. This practice fits in well with the nature of the territory served and the system development patterns followed.

The 774 communities with populations of more than 100 served by the company are widely dispersed throughout the 9,300 square miles of territory. Only eight cities have populations exceeding 20,000; and only one of these exceeds 100,000. The peak load is over 600,000 kw and the annual energy consumption is over $2^2/_3$ billion kilowatt-hours. The framework of the power supply system is a 66-kv network of lines, supplied from scattered generating stations and a 220-kv interconnection. Of the total system load, about 25 per cent is supplied directly to customers from the 66-kv network itself, about 50 per cent at 12 kv, most of which in turn is stepped down from 66 kv, and about 25 per cent at 4 kv, most of which in turn is stepped down from 12 kv, although some is stepped down directly from the 66 kv. This pattern required that all voltages be suitable for direct supply to utilization equipment.

By taking advantage of the nature of the system with its large number of 66-kv step-down substations and by making judicious use of the reactive capacity that is required inherently to relieve generation, transmission, and distribution facilities of the reactive component of load, the use of feeder voltage regulators has been avoided except for some special cases where their use is functionally indicated. This principle is not new in itself; it is only the extent to which this principle is carried out by this company that is distinctive and requires careful system planning and day-to-day operation.

That such a method of voltage control is entirely satisfactory is borne out by the fact that a system peak load of well over 700,000 kva is being carried with less than 60,000 kva of this being served through feeder voltage regulators. In over-all cost, it also is considered more economical.

In practice, the system voltage is controlled at a number of points in accordance with a definite schedule based on time for each point where some means of control is available. These schedules are adjusted as experience dictates in accordance with load variations. At present, there are 32 manually operated control points. Generating stations make up 19 of these. In addition synchronous condenser aggregating more than 125,000 kva are dispersed throughout the system, to supply the major part of the reactive component of load and to control voltage. By 1951, it is planned to reduce the number of manually-controlled points to 22, by relocation of facilities, conversion to automatic operation, shutting down of the older generating stations, and dispersal of automatically controlled switched capacitors throughout the system.

At the present time an extensive program of installing over 90,000 kva of switched capacitors is under way. These capacitors will be well-dispersed around the system and, like the synchronous condensers,will serve the two purposes of voltage control and local supply of reactive load.

Of course, feeder voltage regulators are used in some cases where they are the most expedient means of obtaining the desired end. For example, where load is supplied directly from the busses of large generating stations, where voltages vary to suit the bulk transmission requirements, feeder regulators are used in some cases to avoid "letting the tail wag the dog" and at the same time to provide proper voltage control. Another example is where load is supplied from a tie transmission line on which load flows in either direction in varying amounts and on which voltage cannot be economically controlled to suit the needs of the small tapped loads. In addition, a number have been inherited from predecessor companies; but most of these will be eliminated with the completion of planned facilities required by load growth, in which the facilities for the control of voltage in the manner described will be incorporated.

Plans for the future development of the system call for a continuation as a general practice of the principle of providing adequate voltage by varying the voltage level throughout the system with load and by supplementing this with the judicious use of the reactive capacity required to relieve the system of this burden. By co-ordinated development of the system as a whole, it will be possible to avoid the use of feeder voltage regulators except as a temporary support for a few weak spots and special cases.

Installation of switched capacitors to control voltage on feeders or busses helps not only the local feeders or busses but also the high-voltage systems supplying them. The cumulative effect is appreciable.

Digest of paper **48-264**, "Power System Voltage Control Without Feeder Voltage Regulators," recommended by the AIEE transmission and distribution committee and approved by the AIEE technical program committee for presentation at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

**N. N. Smeloff** is system planning engineer for the Pennsylvania Power and Light Company, Allentown, Pa.

# Impacts of Electronics on Engineering Education

W. G. DOW
FELLOW AIEE

**The all-important contribution of electrical engineering education has been to build up a professional group whose technical ideology is that of analytical thoroughness and correctness in detail, all in one extremely significant, yet very restricted, area of applied science. This thoroughness of training has achieved depth with great success. The advent of electronics, however, demands a broader outlook. Having achieved depth in the past, the engineering schools will be compelled by the impacts of electronics to achieve breadth in the future, and they must find a way to do so without sacrificing the strength to be found in depth.**

TWENTY YEARS of effort toward increasing the vigor and influencing the direction of the impacts of electronics on engineering education have crystallized for me certain guiding philosophies which it is the purpose of this article to express. I present just my own thoughts; I am not voicing the official points of view of the professional and educational organizations with which I have the pleasure of being associated. Critical comment will be welcomed.

Bear in mind that I am, by early training and present interest, a power and industrial electrical engineer, not a radio and communications engineer. I have a nostalgic memory for the abrupt roar of the generators of a hydroelectric station when lightning strikes on the high line; the steady drone of the generators of a metropolitan power station still gives me a homelike sense of security.

Long ago the electrical engineering profession adopted as the cornerstone of its educational structure a requirement that all 4-year students in electrical engineering must acquire a working mastery of 60-cycle a-c power circuit principles and practice. By this single requirement we probably demand of our students greater thoroughness in a difficult discipline of applied mathematics than is required of undergraduate students in any other branch of science. Some years ago I heard a very able theoretical physicist discuss with his class of advanced physics students how electrical engineers have developed very powerful and mathematically elegant methods of electric circuit analysis; he used much the same tone of respect, then, for our standard tools, that might be used now for his own understanding of plutonium atom bombs.

We deserve his respect, for we have achieved strength in depth, but to do so we have limited our field severely. Thus we have selected as our paramount mathematical tool the linear second order differential equation, with solutions in terms of a-c vector diagrams and the imaginary-number operator; relative to all of applied mathematics this is a highly specialized equation. We give primary attention only to the steady-state solution for two standard frequencies, zero and 60 cycles per second. We have had the pleasure of working with a narrowly-selected set of materials: copper, iron, and a few standard insulators, subjected to a very limited range of temperatures, perhaps 300 degrees Fahrenheit over-all. Within this range our materials have almost constant properties. We have worked toward a rather limited set of objectives: of making things go around, of delivering light and heat wherever wanted, and of conveying intelligence. These various elements of narrowness permit mathematical methods to become habitual; thus, there is a point to a criticism once voiced by Doctor C. F. Hirshfeld, while he was director of research for the Detroit Edison Company, that the typical electrical engineer experiences a mental block if faced with a problem not immediately susceptible to mathematical expression. Thus we have insisted, quite successfully, that our students come to know a very great deal about a very little bit of the area of logical analysis as applied to physical sciences. That little bit is very difficult to master, is of immense economic importance, and governs the activities of the thousands of individuals who man the electric power industry.

My theme is that having achieved depth in the past, we will be compelled by the impacts of electronics to incorporate breadth in the future, and that we must find ways to do so without sacrificing our present strength in depth.

## "ELECTRONICS"—WHAT DOES IT MEAN?

Ten years ago the word "electronics" implied the study of the internal behavior of electron tubes. As used today in trade journals, it seems to encompass all of electrical engineering except the highly specialized study of d-c and 60-cycle circuits and machinery. This all-embracing usage as a sort of advertising catch phrase may be unfortunate, but we are having to live with it.

During the recent war the mental work area we call electronics emerged from a chrysalis period during which it had been a segment of the communication arts. We now think rather of communication as one of the important work areas within the electronic arts, but this also will change. I anticipate that the eventual integration of "electronics" into electrical engineering will be, not as a description of an applicational field, but as a partner with

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**W. G. Dow** is professor of electrical engineering, University of Michigan, Ann Arbor, Mich.

circuits, electromagnetic fields, and the electrodynamics of machinery, as one of the several major areas of electrical subject matter. Thus it would seem to me confusing to speak of a power option and an electronics option in our curriculum, because electronic apparatus is of major importance in the electric power industry. If we offer two options, one should emphasize communication, the other power and industrial applications; both must incorporate substantial work in electronics.

### MOTIVATION

Educationally, electronics is a sort of brilliant and ambitious problem child. Electronics is at present a primary motivation in some 60 to 95 per cent of the very large 4-year student enrollment, and in over 95 per cent of the very popular fifth-year master's degree enrollment. This motivation is so strong as to make it difficult to maintain a proper balance in training.

Largely because of electronics, undergraduate enrollment in electrical engineering in the United States is experiencing a "traveling wave" of disturbingly high crest value; the crest will be three to six times corresponding prewar figures. The peak of the wave will hit the industrial market for young engineers either in June of 1949 or June of 1950.

Many young men given war service training in radar and radio now come to the universities for theory. Licensed amateur radio operators ("hams"), study with us; so do boys who have built home voice recorders or radios; and boys who have read about Superman, controlled rockets to Mars, and death rays. These things are obviously electronic in nature, according to the advertisements. This illustrates a relatively new problem in educational motivation; the spread of semiscientific hobbies, and the exposure of boys to popular semitechnical writings, seriously may impair the correlation between economic need and the enthusiasms that bring boys into particular professions. Fortunately there exist at present, in electronics, both motivation and economic need.

The economic need may not persist, but the motivation will remain, and the most important single ingredient in the learning process still will be the enthusiasm of the learner. Therefore, it probably never will be right to destroy a student's enthusiasm for electronics by telling him, even if it becomes true, that he is entering a profession that is overcrowded and characterized by discouragingly intense competition. Besides, teachers who told students that about electronics ten years ago were astronomically wrong, for reasons hidden by the gray curtain that concealed the future. The gray curtain will be before us always.

This motivation problem has a simple solution. We can adhere to a firm policy that each student be trained primarily as an engineer, next as an electrical engineer, including significant attention to electronics. Last, he may be permitted some curriculum choice in his senior year. Properly handled, this can maintain enthusiasm, it will teach the meaning of specialization, and will permit balancing depth and breadth. This policy not only protects a radio ham against changes in economic need; it also chokes down his throat unpalatable items such as fluid mechanics, the thermodynamics of temperature-entropy diagrams, induction motor circle diagrams, and the like. Although as a student he will not believe it, he will need this nonelectronic knowledge very much when earning his living as an electronics engineer, because electronics is not what he thinks it is.

In general, as a student he will not understand that electronics is now as broad as all engineering practice; that it crosses all interprofessional boundaries; that it gives complete allegiance to no one set of scientific tutors; and that it demands of its adherents first of all a sound grounding in broadly general engineering principles.

### EXPANSION OF AREAS OF UTILITY

Electronics has exploded the boundaries of utility and of measurement, and the areas of use of our minds, relative to electromagnetic phenomena. Our curriculum content and our provisions for engineering training must be adjusted accordingly.

The most violent impacts of electronics on engineering practice are due to the radical extensions of the electric circuit frequency spectrum and of extremes of usable power levels. Thus we use electric circuits at frequencies from direct current to 100,000 million cycles per second, and at power levels from a millionth of a microwatt to millions of kilowatts. These and other electronic impacts call for curriculum alterations, and sharply are increasing the needs of industry for electrically-trained men.

### CIRCUITS

The most obvious curriculum change called for is that of strengthening, in depth and breadth, in undergraduate and graduate years, and for electrical engineering students in all options, the study of linear circuit theory, in all possible ramifications as to frequency ranges, band widths, pulse techniques, power levels, transient analysis, equivalent circuits for amplifiers, for acoustical networks, for electromechanical servomechanisms, for microwave cavities, and for what-have-you. This strengthening in depth and breadth we enjoy; we are pleased at having a reason for it.

### ELECTROMAGNETIC FIELD PRINCIPLES

We must strengthen our attention to electromagnetic field theory, on which both circuit and noncircuit electrical engineering is based. Electrical engineers should accept the responsibility of applying to human affairs all technical discoveries in which the gross aspects of electromagnetic field principles are predominant. I believe the advent of electronics, with its emphasis on microwave circuits, wave propagation, and field effects in electron tubes, will compel us to accept this responsibility; we have not hitherto done so.

The seven great commandments of electromagnetic field theory are expressed completely in the seven equations that bear the prophet's name; of course, I refer to Maxwell's equations. In a round-table discussion at the AIEE winter general meeting in Pittsburgh, Pa., last January, Dean Kouwenhoven of Johns Hopkins University supported the thesis, now in effect in his institution, that the formal study of Maxwell's equations be moved from the graduate year to the senior year, to form a required part of the standard 4-year electrical engineering curriculum, for students in all

options. His suggestion is not to be brushed off lightly; such a change would make our standard program terminate coherently with a study of the fundamental tenets of electrical engineering; it would add substantial breadth and preserve depth. I believe it is as inevitable as the rising of the sun tomorrow morning.

### NONCIRCUIT CONCEPTS

Quite aside from power level and frequency changes, the impacts of electronics have exploded the frontiers of noncircuit electrical concepts available to inventive genius. We have reaped a reward of major human importance, if measured in lives paid for national survival, for the imaginations that understood Maxwell's equations well enough to insist on experimenting with radar well before the war. The microwave radar magnetron was a British invention which arose from fruitful mental vision as to how electrons exchange energy with ultrahigh-frequency fields. Like all other electronic inventions, radar is the outgrowth of noncircuit concepts. Let me mention a few of these that our electrical engineering curricula must embrace.

To understand space-charge control of current in vacuum tube, and the focusing of electron beams in cathode-ray tubes, one must emphasize in Maxwell's equations the principles of ballistics, just as used in considering the motion of a baseball in flight into the stands.

In order to understand electronic particle accelerators, many-ton tools of an electrical engineering nature of importance in nuclear transmutation of elements, one must accept the relativistic concepts that an electron's mass increases as its velocity increases, and that the velocity of light appears the same to all observers, regardless of the motions of the observers.

The ultimate limit to sensitivity in any delicate measurements, and in radio and radar reception, lies in signal-to-noise ratio. To understand the origins of noise, whether caused by the raindrop patter of electrons onto the plate of a vacuum tube, or by the randomly-directed current flow in a resistor due to thermal motions of the conduction electrons, or by the gray-body electromagnetic radiations from ocean, land, or clouds, one must acquire at least a little of the logic of random probabilities, and a little knowledge of the kinetic theories of particle motions.

In order to understand the very practical fact of the limits to color response of photoelectric tubes, one must accept the simpler principles of the quantum theory, including the point of view that light energy is received and delivered in "chunks." Industrial spectroscopy, the technology of recording the spectral lines that identify atoms and molecules, is a product of quantum mechanics and a necessary metallurgical engineering skill. Its tools are those of an electronics engineer. The quantum mechanical ideas that permit understanding of fluorescent lights, of ignitrons, of corona, of high-line flashover, and of the new "transistors" are all the same as those of spectroscopy. The elementary quantum ideas are learned much more easily than are a-c vector diagrams; I speak from 20 years of experience in teaching to undergraduates in electrical engineering.

Heat transfer science is neither new nor electronic, but electronics adds to its importance for electrical engineers.

Of course, no one can learn all these things well in the university, but anyone can be taught in the university not to fear trying to learn them later. While our students are still subject to our guidance, we should introduce them with reasonable rigor to enough noncircuit mental concepts to establish a pattern of familiarity rather than strangeness.

### COMPUTER TECHNOLOGY

There is an important research activity in the field of electronic computers, of the digital type, and of the analog type. Digital computers count numbers as the Chinese count on an abacus, while an analog computer makes believe it is itself the physical process to be studied. Both types aid engineering analysis, and aid in empirical evaluations that appear to defy analysis. The important merits of the relatively simple analog computers have been obscured by the publicized wonder and glory of the huge and expensive ENIAC digital computer and its close relatives, which might well have been brought from Mars by Orson Welles. However, one reasonably may hope that before too long it will be possible to obtain a computer that can be put off in one corner of a room, its cost being modest enough so that one can afford to use it only part of the time, and that will solve modestly complicated differential equations with quite arbitrary boundary conditions to slide rule accuracy and in a few minutes.

The introduction of electronic computers may be one of the most far-reaching impacts of electrical engineering on all orderly human endeavors, including the natural sciences, the social sciences, and perhaps even the stock market. Thus, I can imagine a computer on which a business researcher will set up the differential equations of the business cycle, plug into it the initial conditions of 1922, and reproduce on the screen of an oscilloscope the economic boom and bust leading to the New Deal. Perhaps I may be pardoned for suggesting that this is just around the corner.

It is just possible that when the computer business comes of age, there may be more electrical engineers engaged in creating and operating computers than in the entire central station industry. That would represent an extremely important impact on engineering education.

### INTUITION AND ELECTRONIC REFLEXES

On the circuit side, an important impact of electronics has been an immense extension of the use of intuitive, flexible judgment, nonanalytical as to detail, in the arranging and rearranging of blocks in electric circuit block diagrams.

It is impossibly laborious to predict on paper the effects of specific changes in a complex array of individually simple but variegated blocks. It is relatively easy to discover by test the effects of such changes. Therefore, a "bread-board" model is built of any proposed complex electronic circuit design, from which the precise effects of changes are discerned quickly and certainly. There exists in the block-diagram and bread-board habit a process beautifully suited for calibrating objectively, rapidly, and surely, the intuitive notions of the engineer who designs and tests the model. Some men's minds respond to this type of calibration with remarkable ease. Therefore, there has

appeared an important engineering personnel group in which the primary skill is an almost completely intuitive understanding of the internal reflexes of deviously intricate electronic devices.

The appearance, as a typically electrical mental tool, of this intuitive skill, in contrast with logical and rational insight into detail function, is a little new, at least in the university environment. It is a good influence. It encourages electrical engineering students and professors to be more respectful than heretofore of men who rely on quick and objective comprehension of facts, on approximate evaluations, and on judgments born of experience.

### THE CRYSTAL BALL

A strikingly prominent circumstance affecting engineering colleges today is that the demand for electrical engineers interested in electronics substantially exceeds the supply, at the bachelor's, master's, and doctorate levels, even though the supply is far greater than ever before. The demand is for men thoroughly, yet not narrowly, trained. There is, simultaneously, an urgent requirement for us to teach instrumentation and control electronics to students in aeronautical, mechanical, and chemical engineering.

In view of the disturbed state of the world, the importance of military and political influences, and the rapid changes in industrial technology, it is quite impossible for me to predict with any confidence at all for how long or how short a time the "seller's market" for electronic engineers will endure, or at what level of demand stabilization will occur—if it does occur. Some recent attempts at such predictions have been given considerable publicity. None of them command my respect, for I consider the methods of arriving at them unsound. They have been surveys of opinion, I suspect unconsciously weighted in accordance with wishful thinking, rather than being critical, earnest efforts to measure the strength of underlying causative forces. Surveys of opinion measure the plausibleness and dissemination of the statements of prominent men, rather than the soundness of the opinions expressed. We badly need a carefully-organized objective survey of the economic, technological, social, biological, and political forces affecting the responsibilities of our engineering colleges.

In the absence of such a survey, I do not see in my own crystal ball, nor in the reportings of others, any trustworthy indications as to what the demands for men trained in electronics will be, or what our student enrollments will be, in 1958, or even in 1953. My crystal ball does tell me that electronically-induced forces will increase rather substantially the proportion, relative to all engineers, of electrical engineers needed by industry and government. Also I believe that many more electrical students than in the 1920's and 1930's will find resources to continue for a fifth year, and will profit thereby. We may or may not call it a graduate year, and it will not in all cases emphasize technology. I expect a continued increase in the financing of graduate work by means of fellowships and part-time employment in technical work.

There will be an increase in "on-the-job" training of an academic, graduate-level nature, in the larger industrial and governmental organizations. Instruction in such training will come largely from the more able recognized scholars within each organization. There will be more small industrial organizations needing well-trained electrical engineers than heretofore, partly because the investment and working capital requirements for establishing successful small business units are easier to meet in the electronic than in the nonelectronic areas of the electrical industry. The needs of these small units for men with thorough training will have to be provided by universities, because such units do not employ staffs of senior scholars who can give advanced tutelage.

Please note that I mention changes that I believe are coming, whether for the best or not I cannot be sure. There may have to be many changes and counter-changes before stability appears—if it ever does.

### DEMANDS OF AN EVER-CHANGING TECHNOLOGY

I have tried to illustrate what I mean by the statements that electronics will create a strong urge toward our achieving breadth in electrical engineering education, and that we must try to respond to this urge without losing our present strength in depth. There will be many successful responses to the electronically-induced altering forces, but no one and only right response. I believe that to specialize toward or away from electronics earlier in the curriculum than at present would be violently wrong. On the other hand, failure to respond to the demand for change would be absurdly wrong.

The one thing that is vividly clear to me is the simple fact that the pleasant stability of the 1920's, as to enrollment, curriculum, and placement, is gone, probably never to return. Change seems to be the order of the era, for ourselves, for the men who come to us for training, and for the industries our graduates hope to serve. The rewards will go to those men and institutions that expect and accept change gladly as an opportunity for new and greater service.

We appear to be a part of an ever-changing and never-in-balance technology. We must listen always for the changing of the winds.

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## Jet Bomber De-Icer

A new de-icer capable of overcoming the severe icing conditions in the narrow air intake of a jet engine, one of the greatest problems in supersonic flying, has been developed by the aeronautical division of the B. F. Goodrich Company, Akron, Ohio, and is being installed as standard equipment on a new jet bomber. Utilizing electrically heated rubber, thin and tough and with a core of resistance wires running through it, Goodrich engineers fabricated a special rubber lining for the jet's diffuser cowl, through which air flows to the combustion chamber. Jet engines have conked out at high altitudes when the engine's air intake iced up and choked off the vital air supply. Efficiency of the new equipment has held up under heaviest icing conditions in test laboratories and in actual air operation.

# Circuit Duality and Polarity Conventions

WILBUR R. LePAGE
MEMBER AIEE

**By indicating how, but for chance, the present confusion in electric-potential notation conventions also could have arisen in electric current notations, the author seeks to show that our troubles with potentials are man-made. He suggests that the cure of potential-definition ills is to define potential independently of any connected circuit, as is done with current.**

THE SUBJECT of electric-potential notation conventions, long a confusing one, received a ray of enlightenment in an article by Professors W. A. Lewis and M. Reid.[1] In that article there appears a comment, to the effect that there is no confusion in electric-current notation, which prompts the following application of duality principles[2] to put confusion temporarily into notation for currents also, and thereby to show that the troubles experienced with potentials are man-made and, but for chance, could have arisen in the notation for currents. This approach is suggested as an argument against those who worship simultaneously at the shrines of the potential drop and the potential rise. It is not being suggested that confusion is desirable in current notation also, just for the sake of uniformity; but rather that, since current notation could be confusing but is not, uniformity may be gained by putting the potential case in the form which is the dual of the prevalent current case.

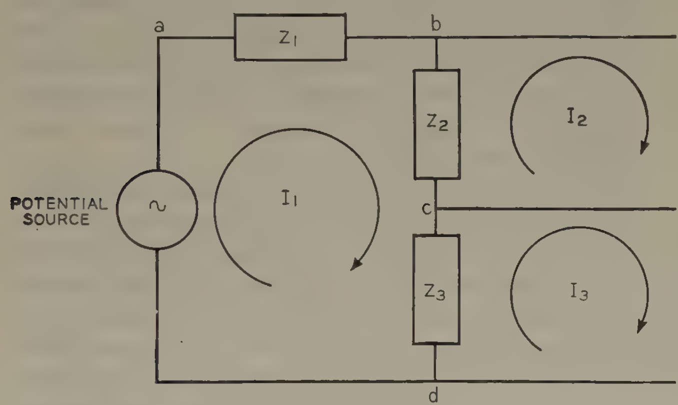


**Figure 1. Analysis of a circuit on a mesh basis**

For reference purposes it is necessary to have at hand the elements of a mesh solution of a circuit having a constant-potential source. Admitting, for the moment, potential rises ($E$) and potential drops ($V$), both always taken in the direction of the order of the appended subscripts, we have, for mesh $l$ of Figure 1,

$$V_{ab}+V_{bc}+V_{cd}=E_{da} \tag{1}$$

or

$$V_{ab}+V_{bc}+V_{cd}+V_{da}=0 \tag{2}$$

or

$$V_{ab}+V_{bc}+V_{cd}=V_{ad} \tag{3}$$

The reader will agree that these equations are all equivalent; but real confusion arises from their slight but subtle differences. To complete the outline of the mesh solution, the potential drops are given

$$\begin{aligned} V_{ab}&=I_1Z_1\\ V_{bc}&=(I_1-I_2)Z_2\\ V_{cd}&=(I_2-I_3)Z_3 \end{aligned} \tag{4}$$

with reference to the current directions shown in Figure 1. It is through these equations that the direction of current is brought into the summations of equations 1, 2, and 3. No mesh current direction is needed to form these equations themselves, but when the voltage-drop symbols are replaced by the $IZ$ products of equation 4 to obtain

$$I_1(Z_1+Z_2+Z_3)-I_2Z_2-I_3Z_3=\begin{cases}E_{da}\\ V_{ad}\end{cases} \tag{5}$$

the assumed current direction becomes significant because a positive potential drop across an impedance is in the assumed current direction. The essence of the arguments in favor of honoring both potential rise and potential drop, as distinct entities, is that equation 5 then may be written with a symbol on the right ($E_{da}$) having subscripts in a sequence corresponding with the direction of mesh current flow in the mesh under consideration.

There is perhaps some advantage to this, but with it must be taken the very great disadvantage that

$$E_{ad}=-V_{ad} \tag{6}$$

so that the sequence of subscripts does not completely specify the quantity.

These effects are well-known. Now, by the introduction of the device of a "counter-irritant" it will be shown that the confusing disease of "bifaciality," from which our potentials suffer, is a situation of chance stemming from the near-constancy of potential of early sources of electric energy, and the consequent mesh-basis analysis of circuits employing them. Suppose constant-current sources had been predominant when the tools of circuit analysis were being forged. Attention would have been directed at the circuit junction (or node) rather than at the mesh, and the resulting equations would have been those of a conventional node analysis. But there could have been incorporated the notational confusion which now will be introduced in a manner which is the dual of the present ambiguous potential notation.

Reference is made to Figure 2 which shows a junction, a ground reference, and a current source. It is the dual of the circuit of Figure 1. To maintain duality of notation it is necessary to introduce letters located on the diagram

**Wilbur R. LePage** is associate professor of electrical engineering, college of applied science, Syracuse University, Syracuse, N. Y.

as shown. Although this is not now common practice, it would have been logical had the junction been originally at the focus of attention. Suppose the junction *1*, the dual of mesh *1*, to be at the center of a circle with the reference letters on its circumference. Let $A_{ab}$ be defined as the current crossing the circumference between points $a$ and $b$ and flowing (in the conventional sense of the motion of positive charges) away from the junction. Making this

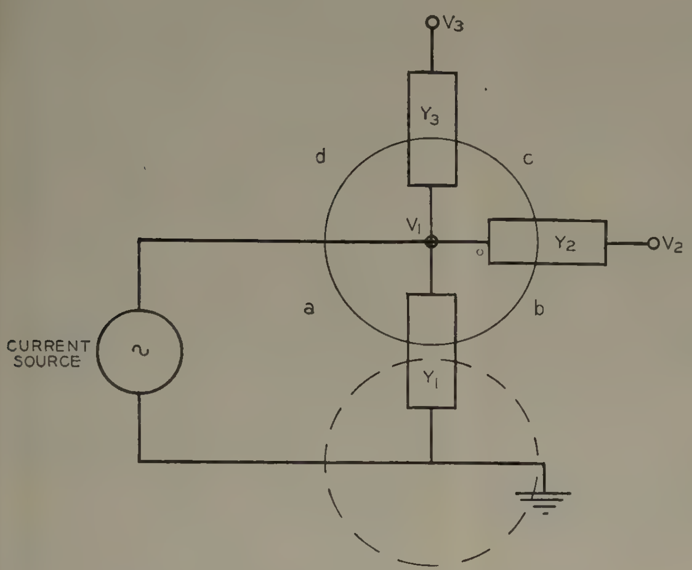


**Figure 2. Analysis of a circuit on a node basis**

more general, according to the proposed convention the current flows from inside a circle on the circumference of which the subscripts read in a counter-clockwise direction. Thus, $A_{ba}$ would be the current flowing from a junction below, as indicated by the dotted circle; and consequently,

$$A_{ab} = -A_{ba} \tag{7}$$

With respect to a junction within the reference circle $A_{ab}$ may be called a current "loss." Accordingly, using the same conventions but traveling in a clockwise direction around the junction, a current "gain" $I_{ab}$ may be defined; and obviously,

$$I_{ab} = A_{ba} \tag{8}$$

Similar situations maintain for the other branches connected to the node. Current gain and loss are the respective duals of potential rise and drop. They have similar dependence both on subscripts and the direction of thought-progress on a circuit diagram.

In terms of the afore-defined quantities the equations of current continuity at the junction become

$$A_{ab}+A_{bc}+A_{cd}=I_{da} \tag{9}$$

or

$$A_{ab}+A_{bc}+A_{cd}+A_{da}=0 \tag{10}$$

or

$$A_{ab}+A_{bc}+A_{cd}=A_{ad} \tag{11}$$

which are the respective duals of equations 1, 2, and 3. Lastly, the duals of the mesh currents of the meshes other than *1* are needed. These are the potentials of nodes *1*, *2*, and *3* with respect to the ground, and, in similarity with the mesh currents, will be designated by a symbol ($V$) carrying a single subscript. This is sufficient because the ground is understood to be the reference in each case. This definition of $V$ is equivalent to the potential drop from the node to ground. In terms of these, in similarity with equation 4, may be written the current-loss equations:

$$\begin{aligned} A_{ab} &= V_1 Y_1 \\ A_{bc} &= (V_1 - V_2) Y_2 \\ A_{cd} &= (V_2 - V_3) Y_3 \end{aligned} \tag{12}$$

and finally the current summation equation:

$$V_1(Y_1+Y_2+Y_3)-V_2Y_2-V_3Y_3=\begin{cases} I_{da} \\ A_{ad} \end{cases} \tag{13}$$

which, when compared with equation 5, completes the formal representation of the duality relationships.

Having arrived at this point, there is now room for confusion on currents. There are two symbols for current ($I$ and $A$) one meaning the negative of the other when they carry identical subscripts; and consequently one may argue whether the sum of the current gains is equal to the sum of the current losses (equation 9), whether the sum of all current losses is zero (equation 10), or whether the current loss of the generator to the junction is equal to the sum of the losses which that junction experiences to its connected admittances (equation 11).

As with the potentials, it may be argued that there is significance in the first of these because there the subscript order on the righthand side ($I_{da}$) is in the same sense on the reference circle as the current losses corresponding to the assumed positive potential on the node. In other words, there is again a linking of current and potential directions in the equilibrium equation. In both types of analysis it is concluded that there is chance of multiplicity of meaning of one quantity when this link is incorporated. In each case it is the second quantity defined that runs into trouble, because of the circuit associations which may be employed in its establishment. For example, in the mesh analysis there is no trouble with the current. It is merely the direction of positive charge motion in a piece of conductor, and, so far as the notational conventions are concerned, there need be no circuit. The same may be said of the potential in the case of a nodal analysis, only the node is needed, no connected admittances being required.

The cure of the potential-definition ills is to define potential independently of any connected circuit, just as now is done with the current. $V_{ab}$ becomes merely the potential of point $a$ with respect to point $b$, without regard to any connections between them, or current flow. This is, of course, the same as the potential drop from $a$ to $b$, so this is the same as the recommendation of Lewis and Reid. The purpose of this discussion is merely to give further argument for its adoption.

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# District Papers Digested for Southern District Meeting

**These are authors' digests of most of the District papers presented at the AIEE Southern District meeting, Birmingham, Ala., November 3–5, 1948. The papers are not scheduled for publication in AIEE TRANSACTIONS or AIEE PROCEEDINGS, nor are they available from the Institute.**

**Southern Bell Applies Electronics;** *John D. Askew (Southern Bell Telephone and Telegraph Company, Atlanta, Ga.).*

We have employed electronics in the United States for nearly half a century. However, the word "electronics" never became really popular until about five years ago.

In the telephone industry, many people think of the telephone repeater as being our first application of electronics. However, it is not. In the Southern Bell Telephone Company, our first application of electronics was probably the Cooper-Hewitt mercury vapor rectifiers. These were introduced about 1905.

*Telephone Repeaters.* A "telephone repeater" is simply a device for amplifying feeble voice currents. In its basic form, it usually contains two voice frequency amplifiers. One of these repeats the speech bound in one direction, such as east, and the other one repeats the westbound speech. We had usable telephone repeaters before the vacuum tube amplifier was invented.

For a commercially practical electronic amplifier, the world had to wait for Lee de Forest. In 1907, he invented the idea of the vacuum tube grid. The grid enables the vacuum tube to amplify and to oscillate, at very high frequencies, with an efficiency that has not been surpassed as yet by any other device. At the present time, the Southern Bell company employs two general types of telephone repeater, the 2-wire and the 4-wire repeater. In both instances, the heart of the repeater is a pair of vacuum tube amplifiers.

Every year, additional needs develop for telephone repeaters. The Southern Bell company now has more than 6,000.

*Carrier Telegraph.* Although telephone repeaters are possible without electronics, the design of a nonelectronic carrier system would be very difficult, even today. However, this is what Alexander Graham Bell was trying to do in 1875 when he suddenly conceived the relatively simple idea of transmitting speech electrically. However, after Bell's experiments, the world still had to wait for another 39 years before the "carrier" idea became a practical possibility. The invention of the triode vacuum tube in 1907 by Lee de Forest supplied the missing link, and the Bell System's first successful carrier system was put together in 1914 by R. A. Heising, of the Bell Telephone Laboratories.

The first carrier system in the Southern Bell territory was a telegraph system from Washington, D. C., to Atlanta, Ga. It provided ten 2-way morse channels, and was placed in service about 1921. The modern type of telegraph carrier system that we use today provides as many as 18 2-way channels. In this system, the 18 carrier frequencies are all audible tones; between 255 cycles and 3,145 cycles. This system represents today's embodiment of Bell's original dream; a harmonic telegraph system.

*Carrier Telephone.* The first telephone carrier system in the Southern Bell area was placed in service about 1924, and its route was also from Washington to Atlanta. It provided three 2-way telephone channels, using frequencies between 3 and 24 kc. This system now has been replaced by a later type, known as the type *C*, which employs frequencies in the range from 4 to 30 kc.

In addition to the type *C*, we also have a later development known as the type-*J* telephone carrier system, which provides 12 more channels, employing a frequency range from 36 kc to 140 kc.

*The Coaxial Carrier System.* There is one recently developed type of carrier system which offers so many potential possibilities that some day it may become more important than all the other types combined. It is known as the coaxial, and derives its name from the physical makeup of the cable over which it operates. This cable employs a hollow copper tube, with a single bare wire running down the center. Thin polyethylene washers are strung on the bare copper wire to keep the wire centered in the tube, but the dielectric between the wire and the tube is chiefly air. Dry air has a much lower loss at high frequencies than any known type of solid material. The carrier current is conveyed over the bare wire, using the tube itself as a return path.

For high frequencies, this type of structure affords two unique advantages; first, the tube serves as a shield, and second, the structure has an extremely low dielectric loss, which is unaffected by variations in the outside atmospheric humidity.

The intermediate repeaters along the route are small unattended installations, energized by 60-cycle power which is fed to them over the same coaxial conductor that carries the high frequencies. At present, by spacing these repeaters about six or eight miles apart, we are able to transmit a band of frequencies about three megacycles wide. However, by improving the repeaters, and possibly spacing them closer together, the width of the transmitter band could be increased to at least six megacycles. The amplifiers in the repeaters along the route are sealed hermetically, and are maintained on a "plug-in" basis, like vacuum tubes.

It is comforting to recall that "one picture is worth a thousand words," because television pictures require a band of frequencies a thousand times as wide as a spoken conversation. Instead of a band about 3 or 4 thousand cycles wide, a television channel requires a band approximately 3 or 4 million cycles wide. At present, we know of only two practicable methods for long haul transmission of such a band. One of these is coaxial cable, and the other is microwave radio relay. The Bell System actively is employing both methods.

*Emergency Portable Radio.* Considering all of Southern Bell's applications of electronics, radio is the most recent. At present, we are using radio for four different types of service. The first one to be developed was the emergency portable service, used for temporarily bridging gaps in long distance lines. At present, the Southern Bell company has ten of these portable units. Each unit consists of a small automobile trailer, containing a 50-watt short-wave radio transmitter and receiver, together with a gasoline-engine-driven alternator.

*Coastal-Harbor Radio.* Southern Bell's second type of radio was inaugurated in 1938, when we established coastal-harbor service at Miami, Fla.

Coastal-harbor service extends regular telephone service to boats, such as tugs, yachts, and fishing craft. The demand for this type of service has increased steadily, and we now have five stations.

*General Mobile Telephone Service.* As soon as telephone service was extended to ships, the telephone company began to receive occasional inquiries from people interested in telephone service for automobiles. At that time, however, a service to automobiles was not technically attractive. The part of the ether which had been explored at that time was very crowded, and all frequency allocations for vehicular use necessarily were restricted to services affecting the safety of life or property, such as police protection. However, during the war, research done for military purposes pointed the way toward methods for utilizing frequencies so high that they previously had been unusable. As a result, thousands of new allocations are now available, employing shorter wave lengths than previously.

Consequently, when the war was over, Southern Bell laid plans for a general mobile radio service, and in 1946 established it on an experimental basis in five cities. The results appeared promising, and general mobile service is now available in seven others.

*Private Line Mobile Service.* For certain people such as doctors and building contractors, general mobile telephone service has proved to be a valuable aid. However, there are others, such as taxicab companies and police departments, which operate fleets of vehicles that do not require connections to the general telephone system. In most cases of this kind, all of the cars in the fleet need a means for communicating with a dispatcher at headquarters, but they do not need connections to outside telephones. Instead of a telephone bell in each car, fleet operators of this kind generally prefer to simply page the desired driver by means of a loud-speaker in each car. Although some fleet operators purchase their radio equipment directly from one of the manufacturers, and set up their

own facilities for installing and maintaining it, others have elected to contract for this service to be furnished by Southern Bell. We now are furnishing this kind of private line mobile service in about 30 towns. In some of them, we have more than one private line system.

**A Load Control Installation in the South;** *T. H. Mawson* (*The Commonwealth and Southern Corporation, Birmingham, Ala.*).

The necessity for automatic load control required the modification of existing governors to provide rapid, accurate response to system requirements. Economical use of stored water was also very desirable.

Using conventional telemetering equipment for the loads in the tie lines, the totalized load was matched against a schedule and correcting impulses were sent to a regulating plant to correct deviations from this schedule.

Since the regulating plant is a hydroelectric plant and since routing of the control impulses to the existing synchronizing motors proved unsatisfactory, a method was devised that provided better response to these impulses. This method consisted of providing a different type of load-limit applied to a governor that had been made essentially isochronous.

This differed from the use of the usual load limiting device in that, irrespective of gate opening, the force attempting to open the gates is constant. When using the ordinary type of gate limit, the synchronizing motor must be set to such a position that the governor mechanism can follow the limiting stop up to the full-gate position. This does not provide uniform response throughout the range of the unit.

The function of the flyballs has not been impaired since they are in control of the unit at all times. By the use of springs balanced against the flyball thrust, if the system frequency drops sufficiently, the unit can move to the full gate position no matter where the limit is set, remaining there until frequency is restored, and then returning to the control position. In addition to this, if the machine trips off the line, the governor is latched in a position that provides a gate opening equivalent to that used for synchronizing. This prevents pumping with possible loss of oil pressure. An oversize by-pass on the dashpot, solenoid-operated, can be closed for synchronizing and opened when the machine is back on the line.

The method of regulating as originally installed was based upon keeping all regulating units in the plant at equal outputs. However, in the lower range of plant output this kept all the units from operating at best efficiency.

Realizing that on any system, interconnected with others or not, the regulating unit would not necessarily operate at best gate, in fact, only by accident, a means was devised to keep only one generating unit in that condition.

The regulating plant considered has three equal units. Two are similar and one slightly different in its efficiency curve. By using cam-operated switches, when the load on the first unit reaches best gate the correcting impulses are sent to the second unit and, if need be, on to the third unit.

The ideas presented cover some possibilities of modernizing older types of hydro governors both with a view toward obtaining rapid, accurate response to control impulses as well as obtaining economical use of stored water. It is difficult to evaluate the savings fully since the integration of these savings vary from day to day with system operation. The basic operation, however, shows the possibility of substantial gains which has been verified by the experimental operation of the plant with this method.

**Application of 2-Way Mobile Radio for Electrical Utilities;** *Blair Jenkins, Jr.* (*Carolina Power and Light Company, Raleigh, N. C.*).

I hope to give in a general discussion the procedure we followed and corrective measures that have been applied in the installation, maintenance, and operation of our radio equipment. The first and most important step is to determine the area to be covered by 2-way radio system. This involves breaking down the system into operating and maintenance areas. These small areas, or districts, normally handle the operation and maintenance of the power system for the local areas, therefore it is essential that the supervisors have local base stations at their disposal for communication to their local equipment. These several base stations should be located where good wire communication is available and also close enough together to afford good communication between base stations during emergency.

In carrying out this plan, equipment was borrowed from the manufacturer to run a number of tests at strategic points covering different types of terrain in order that a coverage map might be made. This map and the data assembled afforded an excellent opportunity for spotting the various base stations.

Several methods may be used in locating an antenna for the base station. The antennas may be located on water tanks, smoke stacks, high buildings, towers, or masts. We chose a mast where other structures were not available. This mast consists of 4-inch and 3-inch heavy duty pipe held in position by five guys in each quadrant. The entire mast with the antenna mounted and the coaxial cable attached is assembled on the ground and raised as a unit. The transmitter-receiver equipment is housed in an aluminum cabinet at the base of the tower. This cabinet is waterproof, has a door at the front and back, and is locked with standard transmission locks. A telephone line then is extended to the remote control units.

The mobile equipment is installed in one of the tool compartments in the front left-hand section of the truck. It is desirable to locate these units as high above the ground as possible to eliminate water and dirt from splashing into the compartment. This also reduces the length of coaxial cable between the set and the antenna. We have found it desirable to install a ground wire of equal carrying capacity between the battery and the set ground, the cables between the set and the control unit on the dash board are wrapped with rubber tape and securely cleated to the body and the chassis, leaving a small amount of slack between the body and chassis to absorb movement and vibration. The antenna is located in such a position as to minimize the whip contacting the body of the car. Insulated hooks are provided for fastening the antenna down when traveling along roads or through wooded areas that might damage the antenna.

We have had some minor troubles with the mobile units. These troubles consist mainly of tube failures, vibrator power supply failures, and capacitor failures. Probably the most serious trouble has been electrolytic condenser failures in the power supply. We also have had some trouble with crystals vibrating out of the sockets.

Generally speaking, the base station equipment has not given any serious trouble. Practically all troubles have been tube failures and blown fuses. The fuse blowing is probably due to the difference in earth potential between the antenna and the main station ground.

It is impossible to estimate the true value of this equipment to the utility industry. We have kept records of the manpower and truck mileage saved by the use of this equipment for about two years, and find that there is, with a $1^1/_2$- or 2-ton truck and a 5-man crew, an annual saving in the order of \$350. With a light truck and a 2-man crew the saving is in the order of \$250. This does not take into account savings due to loss of power sales or customer good will.

**Heavy Electric Equipment as Applied to the Tennessee Coal, Iron and Railroad Company;** *W. W. Garrett* (*Tennessee Coal, Iron and Railroad Company, Birmingham, Ala.*).

To meet the increased demands for steel and basic steel products and to place the mining and manufacturing processes of these products on a relative basis with assembly-line production methods that has resulted in the United States being recognized as the greatest industrial center the world has ever known, it has become necessary to increase the capacity of the mining, transportation, and manufacturing processes of the present facilities far beyond the original designed capacities. This increase has been brought about by extensive mechanization, increasing and redesigning transportation facilities to have a minimum of delay, and by increasing the speed of all rolling processes where possible.

This production increase was made possible by the extensive use of heavy-duty d-c industrial motors ranging from 2,000 horsepower to 7,000 horsepower, and slow-speed a-c industrial motors ranging up to 4,000 horsepower. As such loads are fast, cyclic, and of considerable magnitude, these motors and the corresponding controls were designed specifically for the operation intended.

In the mining industry, coal and ore are surfaced by high-speed electrically driven hoists or by continuous conveyor belts. One of the ore mine hoists has the fastest slope haulage in the world, 4,000 feet per minute. Also, a continuous coal conveyor belt is being installed to deliver 1,000 tons per hour through a vertical rise of 729.4 feet. This is the highest lift and greatest tension on any endless belt in the world.

To increase the manufacture of basic steel products, it was necessary to reduce the rolling time required, or the number of

passes required to reduce the product to the pesired shape. This is to be done without reheating the original product during the rolling procedure, when possible. For example, it is now standard practice to reduce a $7^1/_2$-ton ingot entering the blooming mill at 2,300 degrees Fahrenheit to a coil strip 1/10 inch thick, 30 inches wide, and approximately 1/3 mile long in a series of four separate rolling operations without reheating. This strip is reduced further in a cold rolling process at a rate of 3,000 feet per minute.

The article also gives a number of other large motor drives. Among these is a 2-pole motor-driven blower which is thought to be the largest motor of its type in the steel industry.

Studies of load demand requirements show that in spite of heavy rolling surges produced by individual motor drives, the over-all load demand is fairly steady.

**Unit Substations for Modern Power Distribution;** *Dewey E. Straley* (*General Electric Company, Birmingham, Ala.*).

One of the most revolutionary changes to come about in the construction of power distribution systems has been the introduction of the unit substation. Using standardized, assembly-line methods of manufacture, there is today a complete equipment now available, ready when located at the site, for connections of incoming and outgoing lines. Simplified ordering procedures and superior electrical characteristics, as well as a reduction in the installed cost, are factors which have helped to introduce the unit substation to the electrical industry.

This article has the following objectives:

1. To outline a method of designing a power system to provide a reduction in the initial cost and in so doing to obtain a system of superior electrical performance characteristics.

2. To offer a description of the features of a modern unit substation with special emphasis on the inherent safety features and operational simplicity.

3. To point out that a system, though adequate at the time of installation, may be expanded improperly through the years to the point where it is a dangerous hazard to life and property.

4. To show that through proper arrangement of modern electric equipment, a distribution system can be designed to give a degree of continuity of service unknown some few years ago. Also, to outline the economic comparison of the need for a higher degree of continuity of service with the cost of obtaining such service.

It is hoped that from the foregoing, the following conclusion would be drawn:

That the use of the modern unit substation located at or near the immediate proximity of the load area offers the most economical installation when operational excellence and over-all safety, combined with the advantage of easily expanding the system with load growth, is considered.

**Electrostatic Air Cleaning in the Textile Industry;** *C. H. McWhirter, R. P. Posey* (*Westinghouse Electric Corporation, Atlanta, Ga.*).

Dust costs industry billions of dollars annually in spoilage, maintenance, and cleaning bills. Few industries are more familiar with this fact than the textile industry where spoilage due to dirt long has been recognized as a major problem.

The larger atmospheric dust particles slowly settle or can be removed by mechanical filter systems, but the smaller particles, which are responsible for much damage and human discomfort, until comparatively recently were almost impossible to remove. However, the development of the electrostatic air cleaner has made possible standards of industrial cleanliness heretofore impossible to achieve economically. Experience has shown that substantial monetary savings almost invariably follow its installation.

Electrostatic air cleaners in textile plants can be justified on the basis of improved product quality, reduced maintenance costs, and improved comfort and health conditions. They usually are installed in one or more of three general types of systems:

1. Central systems, which supply entire sections of the plant with air, cleaned (and otherwise conditioned) in line with plant process requirements.

2. Numbers of small individual forced air systems frequently are installed in a single large room. Each individual system usually consists of a large ceiling mounted duct with electrostatic air cleaner.

3. Forced air systems for the drying of yarn require air that is extremely clean. This is particularly true in those installations where air is forced through the yarn packages. Electrostatic air cleaners offer the best, and in many cases the only, available means of insuring clean air for such applications.

Electrostatically cleaned air is particularly justified for those areas of a textile plant in which the operations of throwing, spinning, and twisting are performed. Each of these operations involves high velocity motion of yarn through air, generating high static charges which attract atmospheric dirt particles. This results in sections of yarn of greater than average grayness.

In the foregoing applications it should be remembered that the quality desired in the final product is the controlling factor. Only an examination of each material, textile plant, and the losses due to dirt incurred therein will determine the extent to which the removal of atmospheric dirt particles can be justified.

It is essential to remove lint from the air prior to electrostatic cleaning. For this purpose, a 16 to 20 mesh screen has been found to offer an effective solution. Arc-over rates can be reduced by as much as 10 to 50 times merely by the use of a screen ahead of the electrostatic cleaner. It should be noted, however, that arc-overs usually cannot be eliminated completely.

Great care must be used to prevent the entrance of entrained water droplets into the electrostatic air cleaner as such droplets will cause excessive arcing, corrosion, ionizing wire breakage, and other damage.

Electrostatic air cleaners usually are considered only for the improvement in product quality. However, many air-borne organisms are removed along with the dirt particles with consequent reduction in diseases and respiratory infections.

**Electrical Engineering for Atomic Energy;** *D. W. Cardwell* (*Oak Ridge National Laboratory, Oak Ridge, Tenn.*).

Sufficient time has elapsed since the end of the recent war for security restrictions to be lifted to such an extent that much now can be reported about some of the technical phases of the atomic energy industry.

In Oak Ridge, Tenn., there are three large plants which have been engaged in the production of fissionable materials. The electromagnetic process for separating U-235 represents one of the most impressive achievements ever to be attained in the field of electrical engineering. Unique problems arose in the supplying of power to the world's largest electromagnets which were used in conjunction with production units; and, these production units required a complex array of power and control circuitries with some of the most advanced types of electronic regulators.

The gaseous diffusion process for separating the same isotope was made a practical reality through the use of a vast automatic control and instrument system. Massive high vacuum equipment was maintained leakproof when electrical engineers succeeded in adapting exceptionally sensitive mass spectrographs to the process as leak detectors.

The Oak Ridge nuclear reactor, which has served as a model for other installations throughout the industry, presents interesting problems of automatic control and radiation detection measuring apparatus. Advanced servomechanism techniques involving extensive electronic circuit design are becoming increasingly significant in the study of new proposed nuclear machines.

The development and application of improved radiation measuring instruments offers a great challenge to electrical engineers in all phases of the atomic energy industry. Electronic devices are used to detect and record rapidly recurring pulses, and currents as low as $10^{-17}$ ampere must be measured to a high degree of accuracy. The instrument department of the Oak Ridge National Laboratory, has been a pioneer in the field of radiation detection instruments since the early part of 1943.

In a number of installations in the United States, increasing emphasis is being placed on the construction and use of high energy particle accelerators. Much of this activity is centered at the University of California radiation laboratory, where a most capable group of electrical engineers works in close harmony with nuclear scientists. The exceedingly high energies now being investigated have caused these engineers to design and operate pulse transformers and switching mechanisms to provide unprecedented high wattage pulses. This is possible only as a result of recent wartime radar developments.

In the application of atomic energy to military and peacetime uses, electrical engineers are concerned principally with problems of process control and instrumentation. Much study has been devoted to the subject of production of electric power from nuclear energy. From the long range viewpoint, prospects of success in this field are quite promising, but it is believed that it is impossible even to make a reasonable estimate on an accomplishment time schedule due to the many as yet incompletely evaluated factors. Attention is being directed toward small mobile units for use on ships or aircrafts, as well as large stationary generating stations.

Electrical engineers working in the field of atomic energy find opportunities to employ a wide basic engineering knowledge and are encouraged to engage in scientific phases of the profession in a much more fundamental manner than generally encountered elsewhere. There is a great need for engineers who can understand the basic principles of nuclear reactions in order to make prac-

tical applications of the discoveries of nuclear scientists, and these are bound to have significant effects on our technological development.

**Electricity Is an Integral Part of Agriculture;** *W. J. Ridout, Jr.* (*Edison Electric Institute, New York, N. Y.*).

The backbone of farm electrification is the network of transmission lines carrying electricity from strategically located power stations to practically all cities and towns in the nation. Until a supply of dependable, low-cost power thus could be provided at a center in each farm area, the electrical utilities could not begin a large scale farm electrification program.

The building of transmission lines was completed in the early 1920's and in 1922 the electrical utilities began to build rural electric lines in a co-ordinated national program. By 1930 about one million farms had electricity. Following the depression, the companies, joined in 1935 by the Rural Electrification Administration, again resumed the job of building lines.

At present, with a total occupied farms of 5,600,000, some 2,095,000 receive electric service from the companies and 1,525,000 from REA co-operatives. Other agencies serve 205,000 farms. Thus the total of electrified farms on December 1, 1947, was 3,825,000. During 1948 an estimated 500,000 farms were connected.

Some 725,000 farms have been reached by power lines but do not as yet take service. With only 1,050,000 farms left to reach, the end of the line building task is in sight.

Agriculture today represents an investment in land, buildings, and equipment of over $100 billion. Since 1920 the average farm has increased in size from 148.2 to 194.8 acres, a growth of 31.4 per cent. In the same period farm income has climbed from $16 billion to $24 billion, an increase of 50 per cent. These changes occurred during a period when the nation's population was increasing from 106 million to 139 million—yet farm population declined sharply from 32 to 24 million, a decrease of 25 per cent, and workers per 1,000 acres dropped from 11.8 to 8.5, or 28 per cent.

With fewer workers producing more food for more people, the farmer needs equipment that will increase production with less man-hours of labor. The electrical utilities are bending every effort to make electricity increasingly valuable to the farmer, particularly in the odd jobs and chores that take up 50 per cent of his working hours.

Pumping water, for example, requires an hour of hand labor per 100 gallons, at a labor cost of at least 30 cents. A 1/3-horsepower electric motor will pump this amount for about 1 cent. Ample water will increase milk production by 10 per cent and egg production by 19 per cent, without extra labor.

Electric hay curing will save the 25 per cent of hay lost annually due to rain. An electric motor will hoist a ton of hay into a mow for about one cent. An electric pig brooder will cut losses at least 50 per cent at farrowing time. Many other examples of electricity's ability to increase production, cut cost, and save labor could be cited.

As to future uses of electricity on the farm, many experts predict that the heat pump will prove ideal for farm use, both in the home and in farm buildings housing livestock.

Research into electronics is expected to produce and electronically test for germination growing and production vigor; fertilizers and other plant foods with radiated energy to promote plant health and productivity; water for animals that has been treated with high-frequency waves to promote health; and methods for high-frequency irradiation of soil during plowing that will provide an enemy-free environment for crops to grow.

The trend toward fewer and larger farms will continue, with farms tending to perform more of the processing operations now being done in industrial plants. The electrical requirements of such farms will be high, and will present problems to the electric company distribution engineer. The final result, however, will be a tightly-knit network of electric distribution lines, covering all the agricultural areas of the nation.

**Potential Gradients Within and Around Substation Ground Fields;** *C. C. Jones, C. R. Jager* (*Alabama Power Company, Birmingham, Ala.*).

A ground field of one type or another is required at every electric power installation in order to reduce danger to personnel and limit damage to equipment from overvoltages caused by fault currents.

As adequate grounding is frequently a major item in connection with design of the larger substations, it is essential that sufficient preliminary data be made available so that an effective ground field can be provided at a minimum cost. This requires a knowledge of soil conditions, the depth to which rods can be driven, and the effectiveness of rods in parallel. It is also necessary to know the distribution of potential on the surface of the earth, under fault conditions, in order to determine the extent of control measures necessary to limit this potential to safe values.

Theoretical calculations, generally based on the assumption of homogeneous earth, are valuable for determining trends and for estimating final results from test data. In general, it is not safe to assume soil conditions at any given location even though data are available at other locations in the vicinity.

Spot checks of the area in question by means of test rods will provide reliable information for ground field design. From the data on an average test rod, and the estimated effectiveness of rods in parallel, the number, length, and spacing of rods required to obtain a minimum over-all resistance can be obtained.

Whenever current flows to or from earth, a potential gradient is set up in the earth in the vicinity of the current carrying electrode. This potential gradient is highest near the electrode and, for a high resistance ground or a ground field of limited extent, may be dangerous. In addition to an adequately low over-all resistance, control of this potential may be obtained by closer spacing of underground cables which interconnect ground rods and station equipment, or by the addition of counterpoise wires on or under the surface of the earth. These counterpoise wires are tied to the main ground network at all crossing points. By reducing the size of the counterpoise grids, the potential from any point on the station ground to near by points on the earth's surface may be limited to any desired value. In general, counterpoise grids of 18 inches to two feet square should limit surface voltages to values in the order of one or two per cent of the total available voltage drop.

**The Specialty End of the Electrical Manufacturing Field;** *Gordon Berry* (*The Electric Products Company, Cleveland, Ohio*).

Within the pattern of the electrical industry, we now, with the tremendous demand for all types of industrial electric equipment, have both mass production and specialty needs. Yet these are wedded intimately in that the eventual economic and practical solution of many problems comes from the combined facilities of both types of manufacturing.

With rapid changes coming almost from day to day in the industry, we are more and more dependent on the individual "know-how" of experience; as the problems of yesterday successfully solved are the foundation for solving tomorrow's problems.

The responsibility of the specialty manufacturer therefore becomes one of a concentration of knowledge and experience in narrow fields of application, yet he cannot become too narrow or it becomes difficult to keep abreast of changing times and conditions. Strangely enough this develops a new blood line in the type of individual who finds a fascination in the multiplicity of new problems and in many cases a decided lack of interest in any production of a highly repetitive nature.

The personnel problem is paramount. The salesman requires specialized engineering knowledge—he cannot be daunted by problems of new application requirements.

The design engineer must be right—the first time—because the margin for error is small. He infrequently has the opportunity common to the mass producer, of building a large number of pilot models to be cut and tried until a prototype model is adopted. He must solve most of his problems himself, without access to extensive research and development facilities or specialized talents within the organization.

The production engineer has all of the problems common to the mass producing industry and many others. He must have an intimate knowledge of his plant, every operation and process, in order to control production efficiently. He must develop an organization that has the ability to operate without the detailed instructions that can be developed where large production permits breaking down each component operation to a point where highly skilled labor is not necessary.

Certainly not the least of the team is the purchasing agent. He cannot buy in large quantities so he loses the leverage of mass purchasing. He must have intimate acquaintance with his suppliers because many of them are likewise specialist and necessarily must serve as the research and development department. His inventory problem is a tough one. On many items he cannot afford to carry any or only a minimum stock, yet one item may control the flow of production and completion date of final product.

# INSTITUTE ACTIVITIES

## Our Institute—Our Students

### Student Counselors—Committee on Student Branches—Committee on Education

### *—A Message From the President*

I am finding that when people learn of the Student Members of our Institute they are greatly interested and most pleased. They enthuse that there is so outstanding a group of young men studying electrical engineering in the engineering colleges of recognized standing in our land and as Student Members of our Institute having taken the first step in engineering society membership that their engineering life will be full and complete.

I well remember at the summer meeting of our Institute in 1929 at Swampscott, Mass., sitting on the wide veranda of the New Ocean House and thinking how wonderful was the world, when Professor Harold B. Smith of Worcester Polytechnic Institute, who just had been elected president of our Institute, came to me and gave me the assignment of arranging that our Student Members be granted the privilege of admission to Associate grade without paying the entrance fee of ten dollars. That seemed to be a simple assignment until we found that we could not grant such a privilege to one group without extending it to all others. To overcome this barrier, the corporate membership of the Institute was set up to consist of Honorary Members, Fellows, Members and Associates, and to provide additionally for enrolled students called Student Members, whose privileges are defined separately in our constitution and bylaws.

This happy arrangement has been in effect since that time and it represents a great strength in our Institute structure. Through the years some half of our Student Members have applied for admission to Associate grade and have been accepted to continue on in their engineering society life to advantage.

This year marks another milestone. The committee on Student Branches has recommended and the board of directors has approved the procedure of the Student Member preparing his application for admission to Associate grade at the time of his graduation in June to be acted upon later toward the end of the fiscal year as provided in our constitution. This will facilitate greatly for each Student Member his application for admission to Associate grade and will keep his Institute privileges intact and without discontinuity. Thus does our Institute progress.

We have some 15,000 Student Members. They are associated in our 127 Student Branches in the engineering schools of our land which have been recognized as accredited by ECPD, the Engineers' Council for Professional Development. Thus our high standards are assured. This is another great strength of our Institute.

We also have the provision in our bylaws for joint Student Branches with other national engineering societies. Thus, as the best opportunity is in the engineering schools of our land for joint Student Branch participation, the means for its progression is established, and our Student Members are given early opportunity for joint engineering participation which engineers today visualize as advantageous and desirable.

Undergirding all of these activities stands the Student counsellor who gives much of his time to bringing to the Student Members in his school a knowledge of our Institute and counsel and guidance in the progression of the Student Branch activities. We owe much to these loyal members of our Institute who give so freely of themselves to this most fundamental activity.

Co-ordinating this work is the committee on Student Branches. These loyal members have given of their time in the past to bringing our Student Branch structure to its present strategic position and to progressing it in the present to an appropriately greater future.

Co-ordinating the educational activities available to our Student Members with the educational activities appropriate to our corporate members is the committee on education. An ever greater opportunity is the privilege of the committee on education to progress the continued education of our members that our Institute membership realize in every way its greatest strength.

In the active progression of their Student Branch activities our Student Members come into the participation of our Section meetings through the Section-Student Branch joint action which is carried on by our Sections;

**Everett S. Lee**

and through paper presentations and paper-prize competitions our Student Members come into the participation of the District meetings and the general meetings of our Institute where they are included as a most important part of the program by those responsible for these meetings. Thus, when a Student Member leaves his Student Branch at graduation to enter his further engineering life, wherever he may be he will find himself within the area of a Section where he can continue on his engineering society life as has been his custom.

Each Student Member eligible will have received a letter by this time describing to him the details for his admission to Associate grade in our Institute. The avenue open to him is a broad one with every possible help from his associates for his advancement. As he advances he finds himself aiding others as he has been served, and this is the greatest strength of our Institute—the opportunity to serve.

We welcome our Student Members to our Institute.

# Largest Technical Program Arranged for 1949 AIEE Winter General Meeting

The 1949 AIEE winter general meeting to be held at the Hotel Statler (formerly the Hotel Pennsylvania) in New York, N. Y., January 31–February 4, 1949, will feature a broad program of professional and social activities. The technical program, the largest in the history of the Institute, is a manifestation of the effort of the technical committees of the AIEE to cover the electrical field completely. The tentative program is comprised of 38 technical sessions presenting about 150 papers, and 18 technical conferences.

The Edison Medal presentation ceremonies will take place at a general session Wednesday morning. There also will be talks by President Charles E. Wilson of the General Electric Company and AIEE President Everett S. Lee.

A group of inspection trips has been arranged closely allied with the subject matter of several sessions. On the social side, there will be a dinner-dance, a smoker, theater tickets for out-of-town members, and special entertainment for the women. Meeting headquarters will be in the Hotel Statler. Please note that this is the new name of the world-renowned Hotel Pennsylvania.

REGISTRATION FEES REQUIRED

Members and nonmembers should register in advance by filling in the advance registration card sent with the mailed announcement. In accordance with the policy as set up by the board of directors, a registration fee of $3 will be required for members and a fee of $5 for nonmembers. This is to help make the meeting self-supporting and obviate the need for raising the annual dues. Student Members and the immediate families of members will not pay any fee.

HOTEL ACCOMMODATIONS

Blocks of rooms have been set aside for attending members at five hotels in the Pennsylvania Station area. Members should make their plans early. All requests for reservations should be sent directly to the hotel, and a copy of the letter sent to R. T. Oldfield, Public Service Commission, 233 Broadway, New York 7, N. Y.

The hotel rooms and prices are listed as:

| | |
|---|---|
| **Hotel Statler (formerly Pennsylvania)** | |
| Single room with bath | $ 4.00 to $ 8.50 |
| Double room, double beds | 7.00 to 10.50 |
| Double room, twin beds | 8.00 to 14.00 |
| **Hotel New Yorker** | |
| Single room, tub and shower | 5.00 |
| Double room, double bed | 7.50 up |
| Double room, twin beds | 8.50 up |
| **Hotel Governor Clinton** | |
| Single room with bath | 4.00 to 6.00 |
| Double room, double bed | 6.50 to 8.00 |
| Double room, twin beds | 8.00 to 9.50 |
| **Hotel McAlpin** | |
| Single room and bath | 4.00 to 7.00 |
| Double room, double bed | 6.50 to 10.00 |
| Double room, twin beds | 7.50 to 11.00 |
| Suites | 13.00 to 16.00 |
| **Hotel Martinique** | |
| Double room with bath | 6.00 to 8.00 |

SMOKER

All arrangements are well underway for the very popular "smoker" which will be held this year on Thursday night, February 3, at the Hotel Commodore. Chairman A. Cooper advises that the evening will open with a cocktail hour at 5:30 p.m. in the West Ballroom, with dinner and show to follow. Tables for ten persons will be available to the maximum capacity of the Grand Ballroom. Price of the tickets will be $8 per person. Though every effort will be made

Columbia University's new 400,000,000-volt synchro-cyclotron at Irvington-on-Hudson, N. Y., will be visited during one inspection trip scheduled for the winter general meeting in New York

### Schedule of Sessions

**Monday, January 31**

9:30 a.m. Conference on applied mathematics
Home radio receivers and broadcasting
D-c machinery (A)
Instruments and measurements
Conference on therapeutics
Chemical, electrochemical, and electrothermal conference

2:00 p.m. Conference on fluorescent lighting
Radio communication systems
D-c machinery (B)
Instruments and measurements
Basic sciences
Chemical, electrochemical and electrothermal conference

**Tuesday, February 1**

9:30 a.m. Conference on d-c machinery
Recovery rates on distribution systems
Land transportation
Communication switching
Electronic instruments
Conference on magnetics
Electrical tests on dielectrics in the field conference

2:00 p.m. Land transportation
Transmission and distribution
Radio communication systems
Rotating machinery
Electronic instruments
Conference on magnetics
Electrical tests on dielectrics in the field conference

7:00 p.m. Dinner-dance

**Wednesday, February 2**

9:30 a.m. General meeting
Edison Medal presentation

2:00 p.m. Conference on safety
Carrier current
Conference on d-c motor test program
Special communication applications
Lightning
Conference on heat balance in chemical plants
Industrial control

**Thursday, February 3**

9:30 a.m. Relays
Fractional-Horsepower machinery
Protection of electronic power converters
Industry's active part in education
Industrial control
Symposium on gas turbines
System engineering
Electrostatic precipitation

2:00 p.m. Transmission line protection conference
Industrial control
Conference on education in power electronics
Conference on nucleonics
Symposium on gas turbines
High-frequency cables

5:30 p.m. Smoker

**Friday, February 4**

9:30 a.m. Servomechanisms
Insulated conductors
Switchgear
New electronic devices

2:00 p.m. Conference on textile industry
Symposium on new tools for research
Conference on computing devices
Electronics
Domestic and commercial applications

to meet all demands for tickets, the physical limits of the room have made this difficult for several years past. Reservations should be addressed to the Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Make checks payable to "Special Account, Secretary AIEE."

### DINNER-DANCE

A dinner-dance will be held in the Grand Ballroom of the Hotel Statler (formerly Pennsylvania), Tuesday evening, February 1. Dinner will be served at 7:00 p.m., followed by dancing. Tables for the dinner and dance will accommodate ten persons; the price for the tickets will be $11 per person.

Reservations should be addressed to Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Make checks payable to "Special Account, Secretary AIEE."

### THEATER TICKETS

In the effort again to meet the demands of out-of-town members attending the winter meeting for tickets to popular New York shows, the theater ticket committee under T. J. Talley III, is negotiating the purchase of blocks of tickets to a selected group of the most popular shows.

It is expected that tickets will be available as shown in the following. Please note that orders should be accompanied by checks and will be filled in the order received for even numbers of tickets only unless there are opportunities to combine orders for odd numbers.

**Days**

Monday evening, January 31
Wednesday matinee, February 2
Wednesday evening, February 2
Thursday evening, February 3

| Shows | Price Matinee | Evening |
|---|---|---|
| Annie Get Your Gun | $3.60 | $6.00 |
| High Button Shoes | | 4.80 |
| Inside U.S.A. | 3.60 | 6.00 |
| Life With Mother | 3.60 | 4.80 |
| Light Up the Sky | 3.60 | 4.80 |
| Love Life | 3.60 | 6.00 |
| Mr. Roberts | 3.60 | 4.80 |

### WOMEN'S ENTERTAINMENT

The ladies' entertainment committee, under the chairmanship of Mrs. D. A. Quarles, has arranged an attractive program for the women. The following listing outlines the various activities that are scheduled during the winter general meeting. Other features may be added later.

**Monday, January 31**

"Get-Acquainted" at ladies headquarters

**Tuesday, February 1**

Trip to United Nations (busses will leave the Hotel Statler (formerly Pennsylvania) at 10:00 a.m.)

**Wednesday, February 2**

Tea and fashion show for out-of-town women at Hotel Pierre at 3:30 p.m. through the courtesy of the Westinghouse Electric Corporation

**Thursday, February 3**

Dinner and bridge, 6:00 p.m., Engineering Women Club

### INSPECTION TRIPS

The inspection trips committee under R. W. Gillette has set up an interesting series of inspection trips which will be coordinated as far as possible with the various technical sessions. Places to be visited are

Jamaica substation of the Consolidated Edison Company of New York, Inc., which is scheduled for inspection during the 1949 winter general meeting

**Federal Telecommunication Laboratories (Tuesday, February 1; Thursday, February 3)**

An unusual modern laboratory for research in the fields of communications, aerial navigation, microwaves, and allied subjects.

Features of the laboratory are its aluminum construction with glass wool insulation, interior walls of steel and transite, with provision for easy rearrangement of office and working space, as well as a 300-foot tower with steel structure and aluminum shell for microwave study and developmental work.

**Jamaica Substation, Consolidated Edison Company of N. Y., Inc. (Monday, January 31; Tuesday, February 1)**

A new substation having a double-deck arrangement of 138-kv and 27-kv busses and metalclad isolated-phase 27-kv equipment installation. Pumping plant equipment for maintaining pressure on the high-pressure pipeline-type 138-kv feeders and gas supply equipment for outgoing 27-kv gas-filled cables will be seen.

**Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y. (Thursday, February 3)**

Special arrangements have been made to inspect the new and modern material laboratory where all naval engineering materials and equipment are given exhaustive tests for compliance with specification. The trip will include the applied mechanics section, power and communication cable testing, electronic, acoustical, and illumination sections, servomechanisms, and high-power tests.

**Meter Division, Westinghouse Electric Corporation, Newark, N. J. (Wednesday, February 2)**

The Westinghouse meter division occupies two city blocks near the Lackawanna Railroad Station in Newark, N. J. It was the first and therefore the oldest works outside of the main plant at East Pittsburgh, Pa.

Since 1926 the corporation's activities in electrical measurements have been centered at the meter division with manufacturing operations devoted exclusively to protective relays, watt-hour meters, and electric measuring instruments.

A view of one of the instrument calibration departments in the Westinghouse Electric Corporation's meter division at Newark, N. J., which is the subject of a winter general meeting inspection trip

**Columbia University Cyclotron (Wednesday, February 2)**

Columbia University's new 400,000,000-volt synchrocyclotron now in final stages of completion and testing. Visitors will see the large electromagnet having a 2,500-ton steel yoke, 300-ton copper exciting coils, and 160-inch diameter pole face having a field strength of 18,000 gausses. Employs a unique frequency-modulated accelerator voltage supply with approximately 100 per cent frequency swing achieved by means of two rotating motor-driven variable capacitor systems 14 feet long in a high vacuum chamber.

Associated buildings and laboratory will be open for inspection.

COMMITTEES

The personnel of the 1949 winter general meeting committee includes

A. E. Knowlton, *chairman* (also *chairman, medal awards co-ordinating committee*); G. J. Lowell, *vice-chairman;* H. W. Farrer, *secretary;* W. J. Barrett, *budget co-ordination;* D. T. Braymer, *registration, meetings;* A. J. Cooper, *smoker;* E. T. Farish, *dinner-dance;* R. W. Gillette, *inspection trips;* R. K. Honaman, *press relations;* R. T. Oldfield, *hotel reservations;* J. J. Pilliod, *general sessions;* C. S. Purnell, *reception;* T. J. Talley III, *theater, radio;* H. M. Turner, *technical program liaison*

The inspection trips committee consists of

R. W. Gillette, *chairman;* A. S. Brookes; H. E. Farrer; W. Hayden, Jr.; C. N. Hoyler; F. P. Josslon; D. E. Sullivan; W. G. Short

The members of the smoker committee are

A. J. Cooper, *chairman;* W. J. Barrett; Carl Bolles; J. B. Harris, Jr.; S. L. Henderson; William Jordan; J. M. Danser; J. P. Neubauer; E. G. D. Patterson; D. M. Quick; H. B. Snow; D. W. Taylor; E. F. Thrall; W. R. VanSteenburgh; C. T. Hatcher, *ex officio*

On the theater and broadcast tickets committee are

T. J. Talley III, *chairman;* G. J. Dyktor; H. E. Murphy; J. Paszkowski; William H. Van Tassel

The dinner-dance committee includes

E. T. Farish, *chairman;* E. S. Banghart; J. M. Comly; J. G. Derse; L. F. Hickernell; W. L. Lawrence; H. L. Lowe; M. S. Mason; J. F. Moore; James Nesmith; Ernest Ohnell; G. H. O'Sullivan; W. H. Taubert; T. A. Taylor

The ladies' entertainment committee is composed of

Mrs. D. A. Quarles, *chairman;* Mrs. E. S. Banghart; Mrs. D. T. Braymer; Mrs. R. F. Brower; Mrs. O. E. Buckley; Mrs. J. L. Callahan; Mrs. A. J. Cooper; Mrs. A. F. Dixon; Mrs. J. F. Fairman; Mrs. A. E. Knowlton; Mrs. G. J. Lowell; Mrs. G. T. Minasian; Mrs. R. T. Oldfield; Mrs. H. S. Osborne; Mrs. J. J. Pilliod; Mrs. C. S. Purnell; Mrs. E. H. Snyder; Mrs. George Sutherland; Mrs. M. J. Talley III

## Future AIEE Meetings

**AIEE Conference on High-Frequency Measurements**
Roger Smith Hotel, Washington, D. C.
January 10–12, 1949

**Winter General Meeting**
Statler Hotel (formerly Pennsylvania Hotel)
New York, N. Y.
January 31–February 4, 1949
(*Final date for submitting papers—closed*)

**AIEE Conference on the Textile Industry**
Atlanta, Ga.
Spring, 1949

**AIEE Conference on the Rubber and Plastics Industry**
Akron, Ohio
March, 1949

**AIEE Conference on the Industrial Applications of Electron Tubes**
Buffalo, N. Y.
April 11–12, 1949

**South West District Meeting**
Baker Hotel, Dallas, Tex.
April 19–21, 1949
(*Final date for submitting papers—January 19*)

**AIEE Conference on the Textile Industry**
Boston, Mass.
May 4, 1949

**Summer General Meeting**
New Ocean House, Swampscott, Mass.
June 20–24, 1949
(*Final date for submitting papers—February 20*)

**Pacific General Meeting**
Fairmont Hotel, San Francisco, Calif.
August 23–26, 1949
(*Final date for submitting papers—April 23*)

**Midwest General Meeting**
Netherland Plaza Hotel, Cincinnati, Ohio
October 17–21, 1949
(*Final date for submitting papers—June 17*)

**Winter General Meeting**
New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—September 30*)

# Birmingham, Ala., Acts as Host to AIEE Southern District Meeting

"The Industrial Renaissance of the South," was the theme of a 3-day meeting of the Southern District, held at Birmingham, Ala., November 3–5, 1948. In addition to the opening session, five technical sessions were held with many papers exemplifying the theme of the meeting. Two banquets were held on Wednesday and Thursday evenings with appropriate addresses, and inspection trips were arranged on Thursday and Friday afternoons to important research projects and engineering installations. An active time was provided for the women in the form of luncheons, a shopping tour, a tour of the city, a fashion show, and a visit to the largest hat factory in the South. The meeting was attended by a total of 334 members, students, and guests.

OPENING SESSION

The address of welcome was given by the Honorable Cooper Green, president of the City Commission of Birmingham, who was one of three mayors chosen by the Secretary of State to represent the United States at the Paris City Conference. Mr. Green expressed pride that the meeting was held in Birmingham to discuss problems, and to make progress. He explained that these were troubled times, but there was no fear as long as groups could meet and get together to discuss mutual problems.

The general chairman of the meeting, F. B. Weiss, outlined the program of events for both the men and the women. The program presented a full schedule, something happening every hour, but the parallel sessions offered opportunity for ample time to discuss papers.

Vice-President J. H. Berry of the Southern District, elaborated on the chosen theme for the meeting, "The Industrial Renaissance of the South," and explained that the percentage gain in membership in the Alabama Section last year was greater than that for any other Section. Mr. Berry drew attention to the contribution of each of the specialized fields of engineering in the region. He expressed the need for a pleasing appearance in design. When designing substations, buildings, and structures, the appearance should be kept in harmony with the surrounding area, and if the lines are unsightly, the designs are in error.

President Lee addressed the meeting on the subject of "Our Institute," and told of his personal experiences while visiting a number of the Sections in the Pacific Northwest, as well as along the South Atlantic seaboard. He said that a spirit of friendliness prevailed 4,000 miles away from home, which made him feel just as though he were at home. The importance of team-work was emphasized, by Mr. Lee, and the need for engineers to have other activities, to be sure that they are well-rounded engineers, was drawn to attention. President Lee explained that the budget had been balanced for the coming year, which led to the thought that some expenses might be allocated more directly, such as the \$2 member registration fee, and \$3 nonmember registration fee for the District meetings. Other expenses have been saved, such as reducing the number of pages in *ELECTRICAL ENGINEERING*, and so it will not be necessary to increase dues as yet. With regard to an over-all engineering society, the matter has been referred to the Engineers Joint Council. In conclusion, President Lee urged that members should not wait for the over-all engineering society to bring them recognition, but that time should be given to work with fellowmen, and recognition will follow.

AIEE Secretary Henline expressed his pleasure on returning to Birmingham and finding a good audience. He commented on the fact that the Institute was growing still more rapidly in the interests and activities of its members.

The speakers were introduced by H. J. Scholz, chairman of the Alabama Section, who extended a welcome in behalf of the Section to members and guests in attendance.

BANQUET, WEDNESDAY EVENING

One of the features of the banquet held on Wednesday evening, attended by both men and women, was an address, "Industrial Research in the South," given by Thomas W. Martin, president, Alabama Power Company, and chairman of the board of trustees of the Southern Research Institute. Changes which had taken place through the establishment of the Southern Research Institute were described by the reaction of an old friend who had returned to Birmingham, and was taken

Photo by John Faber

**Research in progress at the Southern Research Institute which was visited on one of the inspection trips, and described at the banquet, carries out the general theme of the Southern District meeting**

on a tour of the institute. He indicated great surprise at the changes, and inquired if this was a change going on throughout the South. Mr. Martin referred to the "Cancer Research Program" which has been going on for three years, and is attracting increasing attention in the United States and abroad. He maintained that the South must do something about processing raw materials, rather than sending them out to be processed elsewhere, and he pointed out that some nine years ago only two per cent of the research, and about two per cent of the patents were from the South. The time is coming, according to Mr. Martin, when the purchasing power in the South must be changed. He explained also, how the Southern Research Institute was established largely by the aid and promotion of men in the South who are in the electric power business.

What the chemist can do for the electrical engineer was discussed by Doctor Murray of the Southern Research Institute. When an engineer reaches the limit of his design, then he must have new material. Southern pig iron has an unusually high phosphorous content, making it difficult to machine, because it exerts a dulling action on the cutting edges of high-speed machine tools. The institute has developed an inexpensive and practicable process for improving the machinability of this iron by adding a small amount of zirconium metal to alter its microstructure. Doctor Murray referred to other projects, such as the heat pump which has been working for three years. He indicated that, if every house had one, it would triple the electric load. Studies are being made of the economics of the problem.

Research in connection with cellulose and wood preservation was described by Doctor R. C. Stroull. He explained that the institute was interested vitally in all methods of insulation preservation and the development of new products from wood.

The experiment in underground gasification being conducted by the United States Bureau of Mines and the Alabama Power Company at Gorgas, Ala., was described by Doctor Nelson H. Fies, manager of coal operations. Degasification of coal was explained as starting a fire underground to produce synthetic liquid fuel, and that approximately \$2,000,000 would be spent on such experiments in the next few years.

In conclusion, it was stated that the voice of science and technology is abroad in the South. People are beginning to realize its significance and are doing something about it. Everyone is standing to move forward preserve tradition, and improve the standards of living.

DISTRICT EXECUTIVE COMMITTEE MEETING

The meeting of the Southern District executive committee was held on Thursday, with each of the 12 Sections represented, except Muscle Shoals.

Considerable discussion with respect to the formation of Subsections and new Sections brought out the point that even though there were a number of members available at a given location, unless one or two men would show sufficient interest to give the time and effort necessary, formation would be difficult, if not almost impossible. The possibility of three or four new Sections in District 4 was mentioned, although no specific action was taken. Mention was made that the Citadel was coming in as a Student Branch under the Charleston Subsection. Also, Louisiana Polytechnic Institute has had its electrical engineering curricula approved by the Engineers Council for Professional Development.

Professor Walter J. Seeley of Duke University was nominated for vice-president of District 4. C. P. Knost of New Orleans, La., was elected to serve on the national nominating committee. He was instructed to place the name of H. J. Scholz before the nominating committee as a candidate for director.

General discussion of District affairs centered around new Section formation; the possibility of inviting some of the younger members to sit as guests at District executive meetings so that they could see how District affairs were handled; and the possibility of additional representation on the executive committee from the Sections.

The District showed an increase in membership for the past year of 15.4 per cent, moving up from 1,688 to 1,948.

THURSDAY EVENING BANQUET

"The Southern College and Southern Industry" was the subject of an address given by Doctor John M. Gallalee, president of the University of Alabama. Doctor Gallalee cited the fact that electrical engineers and associates have done a great deal to bring about industrial renaissance in the South. Attention was drawn to the financial support of collegiate institutions, as well as the educational qualifications, as compared with those in other sections of the United States. Some progress has been made, but he explained that there is an enormous way to go if conditions are to equal those of other sections of the country. He commented on the number of veteran students who are mature, and have a great sense of responsibility, thus constituting one of the finest groups he has ever had.

Doctor Gallalee pointed out that enormous progress is being made in getting many excellent young people from the high schools, but the drain on the region is very great. Efforts are made to give as broad a training as possible to students, so that they will be better men. He commented on the 5-year course,

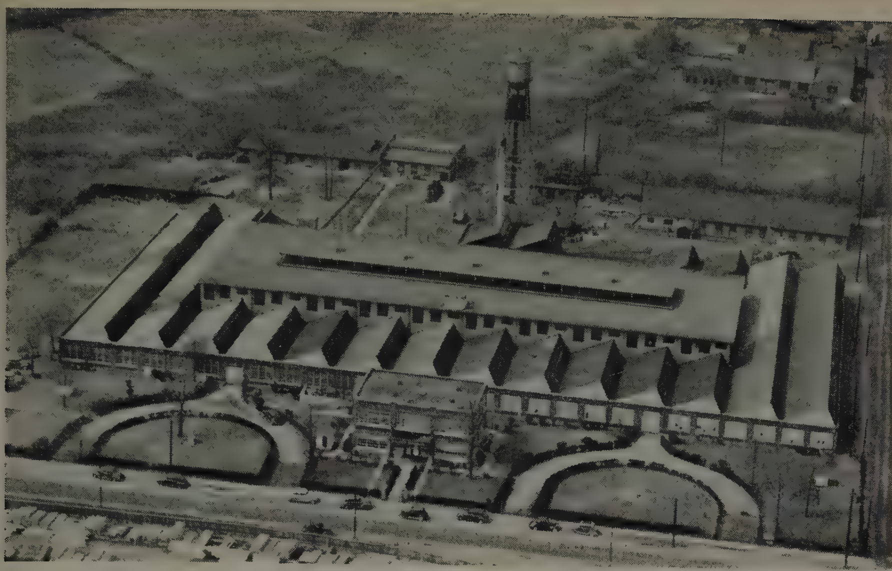
## AIEE PROCEEDINGS

Order forms for current AIEE *PROCEEDINGS* have been published in *ELECTRICAL ENGINEERING* as listed below. Each section of AIEE *PROCEEDINGS* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *TRANSACTIONS*.

AIEE *PROCEEDINGS* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student Members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *PROCEEDINGS* will appear in *ELECTRICAL ENGINEERING* in abbreviated form.

| Location of Order Forms | Meetings Covered |
|---|---|
| Apr '48, p 49A | Winter general |
| Aug '48, p 45A | Great Lakes District<br>North Eastern District<br>Summer general |
| Oct '48, p 43A | Pacific general<br>Middle Eastern District |
| Dec '48, p 35A | Midwest general<br>Southern District |



**The new location of the Southern Line Material Company in Birmingham, Ala., 160,000 square feet floor area with an office building completely air-conditioned and sterilamped for air purification exemplifies "The Industrial Renaissance of the South"**

and explained that the smaller companies have difficulty employing men who cannot become immediately productive. In general, much more brain capacity is exported than can be imported in the region. Attention was drawn to the difficulties of getting into good schools in other sections of the country, and to the fact that the South must raise the level of its own schools.

In conclusion, Doctor Gallalee commented on the fact that engineering students are too modest when entering employment. He appealed to the employers of graduates to study them carefully, and guide them in the beginning of their efforts. Southern people have some very desirable traits, such as their friendliness and ability to get along with others. The graduates need help and encouragement, as well as the schools, and hope was expressed that the necessary assistance would be given.

President Lee addressed the banquet on the ways in which engineers can obtain recognition of their achievements. He spoke from personal experience, and explained how he had cemented friendships by addressing the various service clubs on engineering accomplishments. He stated that every engineer has it within himself to do likewise, if he would devote a little time and thought to the matter. By so serving, recognition will come his way in more ways than possibly can be foreseen. In conclusion, President Lee paid tribute to Vice-President Berry for his work in the District, and service on the board of directors. He remarked on the grand qualities of friendship of Mr. Martin and Doctor Gallalee, and he requested that everyone present resolve to put his hand to the wheel, so that these men will be happy in their ministry.

Vice-President Berry acted as toastmaster, and introduced those present at the speakers' table. Attention was drawn to the plaque for the greatest percentage increase in membership last year, 1946-47, which was held by the Alabama Section, and it was explained that the plaque would be taken away to the Louisville Section.

**Analysis of Registration at Birmingham, Ala.**

| Classification | Ala. Section | District 4* | Other Districts | Total |
|---|---|---|---|---|
| Members | 93 | 74 | 11 | 178 |
| Student Members | 39 | 16 | 3 | 58 |
| Men guests | 31 | 16 | 2 | 49 |
| Women guests | 41 | 8 | | 49 |
| Totals | 204 | 114 | 16 | 334 |

* Outside Alabama Section.

TECHNICAL SESSIONS

Five technical sessions were held during the meeting. Many papers were presented in these sessions which exemplified the general theme, "The Industrial Renaissance of the South."

In the Wednesday afternoon sessions, John D. Askew described the early history, and electronic applications to various apparatus in use by the Southern Bell Telephone and Telegraph Company.

In the power field, T. DeWitt Talmage described the carrier channels used to establish the major portion of a 6,500-mile telemetering and automatic load-frequency-controlled system in Tennessee, and portions of bordering states. These facilities provide a high degree of operating flexibility and insure a maximum efficiency in generating and controlling power. The application of carrier line traps was stressed. In a paper on "A Load Control Installation in the South," T. H. Mawson advanced ideas for modernizing old governors on hydroelectric units. C. P. Jones and C. R. Jager, of the Alabama Power Company, assembled an important paper on the subject of "Potential Gradients Within and Around Substation Ground Fields." On the theoretical side, papers were presented on "A Linear Analysis of a Tuned Plate Oscillator," and "The Operational Amplifier," by Craig Harris, University of Tennessee, and Nicholas J. Gagliano of Tulane University, respectively.

Papers of particular interest in the field of light and power were presented Thursday morning. Several combinations of "Unit Substations With Their Attendant Economic Advantages" were described by D. E. Straley. Developments in the design of large power transformers were described by Gordon W. Clothier. He explained that the use of oriented steel would permit higher flux densities and reduce the core size about 25 to 35 per cent, also improvements in insulation were described. Another paper presented information on an extensive 2-way mobile radio system installed on service trucks of the Caroline Power and Light Company. Still another paper, by Rhea P. Lapsley of the Okonite Company, described the "Oilostatic Cable System" with particular reference to installations in the South. On the basis of generating capacity installed compared with the number of high oil-pressure pipe-encased cable circuits, the South is keeping pace with the heavily industrialized northern section of the eastern seaboard and is far ahead of other sections of the country in adoption of this modern system for transmission of electric power.

Among the papers presented at the two sessions on Friday morning, D. W. Cardwell of the Oak Ridge National Laboratories, reviewed "The Requirements of the Atomic Energy Field." He concluded that there is a great need for electrical engineers in this field, who have a sound basic knowledge of electrical fundamentals. They should be capable of understanding the more scientific aspect of nuclear reaction, so as to provide electrically controlled systems and instruments. Other papers dealt with "Electric Mass Transportation," "Agriculture," "Ship Building and Ship Operations," "Electrostatic Air Cleaning in the Textile Industry," "Sectional Paper Machine Drives," and "Heavy Electric Equipment as Applied to the Tennessee Coal, Iron and Railroad Company."

INSPECTION TRIPS

Many members and guests took the inspection trips to the Radio Center atop Red Mountain, where amplitude modulation and frequency modulation and television broadcasting equipment is in service, or being installed. On this trip, the Southern Research Institute also was visited, as well as the 110-kv oilostatic cable installation of the Birmingham Electric Company.

Another trip was provided to the underground coal gasification experiment of the United States Bureau of Mines, and the Alabama Power Company at Gorgas, Ala. On Friday afternoon, arrangements were made to visit the Tennessee Coal, Iron and Railroad Company, hot strip and tin plate mill just outside of Birmingham.

**Bellaschi Completes Lecture Series.** P. L. Bellaschi, consulting engineer of Sharon, Pa., has completed a series of talks before various AIEE Sections in the Southwest, Rocky Mountains, and on the Pacific Coast. His addresses covered progress and recent developments in the field of power transmission at very high voltages in the United States and abroad, especially in Sweden, France, and Switzerland. He also touched on projects involving long-distance power transmission now under consideration in Egypt, South America, and elsewhere.

## Schenectady Section Fetes President Lee

A testimonial dinner honoring AIEE President Everett S. Lee was given by members of the Schenectady (N. Y.) Section and attended by approximately 200 members and, special guests on November 22, 1948, at the Schenectady Van Curler Hotel. Highlights of the evening included speeches by Mr. Lee and Owen M. Begley, mayor of Schenectady, and the presentation to Mr. Lee by J. C. Page, vice-chairman of the Section, of a gold-plated gavel.

Other guests present included J. L. Callahan of the Radio Corporation of America and a vice-president of AIEE, District 3; D. C. Prince, vice-president in charge of the general engineering and consulting laboratory, General Electric Company; R. M. Kelso, president of Schenectady's Kiwanis Club; and H. J. Linton, superintendent of schools.

Mr. Lee's address stressed the necessity for engineers to concern themselves with civic duties as well as those involving their technical specialties. He pointed out the great contributions that engineers were making to the advancement of civilization and progress but he warned that "they are not telling anybody about it." He expressed the hope that engineers would "get out and meet the people" by adding their respective skills to community welfare projects.

The speakers preceding and following Mr. Lee were warm in their praise of his efforts in behalf of the engineering profession and civic development. In summing up his valuable contributions to the scientific world, Mr. Lee was cited as being "a leader among American engineers."

## Report on Telemetering Available as Pamphlet

"Telemetering, Supervisory Control, and Associated Circuits," a report summarizing information as to electric telemetering and supervisory-control systems commercially available in the United States, now is obtainable in pamphlet form. The work is based upon a report compiled by an AIEE subcommittee in 1932 and revised in 1941. The present revised report, corrected to May 1948, was prepared by the joint subcommittee on telemetering of the AIEE substation and instruments and measurements committees.

The information in the report has been arranged in four main sections: telemetering, supervisory control, load-frequency control, and information concerning circuits and channels for telemetering and supervisory-control systems.

A copy of the report may be obtained from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. It is priced at $2 per copy; $1 to AIEE members.

## Fellowship Applicants Must File by February 15

Candidates for the Charles LeGeyt Fortescue Fellowships should file applications on the form provided by AIEE so that they reach the secretary of the fellowship committee by February 15, 1949. Awards will be made not later than April 1. Copies of the application forms are available at accredited colleges or at AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end the Westinghouse Electric Corporation, with which Doctor Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates, selected by the AIEE committee which administers the fund, receive a minimum allowance of $500 and additional allowance may be granted at the discretion of the committee.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the fellowship committee. To be eligible the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institition at which the graduate work is to be undertaken.

J. C. Page, vice-chairman of the AIEE Schenectady (N. Y.) Section, presents AIEE President Everett S. Lee with a gold-plated gavel at the testimonial dinner honoring him

## Centre County Subsection Elects Officers for 1948–49

The AIEE Centre County Subsection (State College, Pa.) which was organized last April has elected the following officers for 1948–49: R. E. Armington, *chairman;* R. J. E. Hemman, *vice-chairman;* W. B. Shepperd, *secretary-treasurer.* All are with The Pennsylvania State College, State College, Pa.

Recent meetings of interest held by the Subsection include the October 26 meeting on medicine and science at which Doctor V. M. Albers of the ordnance research laboratory at The Pennsylvania State College delivered a paper on "Co-operation Within the Scientific and Medical Fields." At the same meeting, E. G. Thurston discussed and demonstrated the new electroacoustic gallstone detector developed by the ordnance research laboratory in co-operation with C. K. Kirby of the University Hospital of Philadelphia. Much interest was displayed in this new invention by both medical and scientific personnel. At the November 16 meeting, L. S. Linbeck of the Westinghouse Electric Corporation discussed, "Variable Speed Drives for Wind and Tunnel Applications."

All technical meetings are held jointly with the local Institute of Radio Engineers subsection of Centre County.

## Radiant Heating Committee Inspects Ford Motor Plant

Sixteen members of the AIEE radiant heating committee were the guests of the Ford Motor Company on October 21 at its Lincoln-Mercury division plant at St. Louis, Mo. The committee commended The Ford Motor Company on its pioneering and development of electric infrared heating. The meeting and plant visitation were part


**Ford Motor Company commemorating tenth anniversary of industrial infrared heating, plays host to AIEE radiant heating committee. Seen here are, front row left to right: William H. Wagner, L. E. Cole, E. J. Bates, L. E. Stout, J. E. Johanson, Earl Benson, V. G. Richardson (Ford Motor Company). Second row left to right: P. O. Blackmore, W. H. Wannamaker, P. H. Goodell (committee chairman), Charles E. Russell (committee secretary), O. C. Wallace, Charles A. Casey. Back row left to right: I. J. Barber, C. Heaton, E. A. Linsday, J. E. Sump, R. J. Might, W. F. Hickes, C. T. Prendergast**

of the tenth anniversary celebration commemorating the use of this type of heating first installed at the company's River Rouge plant.

The Institute committee, which is sponsoring further development of electric heating, is made up of representatives from equipment manufacturers, electrical utility companies, instrument manufacturers, engineering professors from several leading universities, lamp manufacturers, advisors from the paint and textile industries, and leading industrial users of electric radiant heating.

The committee was appointed by AIEE President Everett S. Lee, and its activities are directed by Paul H. Goodell of The Trumbull Electric Manufacturing Company, as chairman, and Charles E. Russell of the Philadelphia Electric Company, secretary.

The committee inspected eight of the new type ovens which combine controlled convection with infrared heating to provide better curing of synthetic enamel finishes with reduced time and floor space requirements. The power demands of the new ovens have been reduced over 40 per cent with the result that a single coat of enamel is baked on a sedan body with an energy consumption of only 16 kilowatt-hours. The eight ovens handle a heating load of approximately 60 tons per hour, with a maximum demand of 3,000 kw. This represents a production of 40 cars per hour with two coats of finish baked with the electric heating at 325 degrees Fahrenheit. The ovens are reported to save approximately 20,000 square feet of floor space as compared with former types of convection heating. The ovens are used for baking the finish on bodies, fenders, hoods, wheels, and other sheet metal parts. They range in size from 100 to 700 kw each, and in length from 25 to 170 feet. Paul S. Mabie, manager of the St. Louis plant, was the committee's host.

## District 2 Holds Meeting of Student Activities Committee

The meeting of the District committee on Student activities for AIEE District 2 (Middle Eastern) was held under the auspices of Lehigh University, Bethlehem, Pa., November 5–6, 1948. Members of this committee are the Student Branch chairman and the counselor of each Student Branch in the District, plus the District vice-president and the District secretary. The meeting was open to all Student Members and other AIEE members who wished to attend. All arrangements for the meeting were made by members of the Student Branch at Lehigh University, with the guidance of Professor J. L. Beaver, Student counselor, who was also chairman of the 1947–48 District committee on Student activities.

Following a period on Friday morning which was devoted to registration and inspection of the Lehigh University campus, the conference of Student Branch chairmen was held. Topics covered at this conference included:

1. How to get greater co-operation of the Students in Branch activities.
2. How to get greater co-operation by the Section and Section members in Branch activities.
3. Membership activity in the Branch.
4. Branch prize paper competition, 1948–49.
5. Why every Student member should join AIEE as an Associate member upon graduation; how this transfer of membership should be accomplished; the importance of the Institute keeping an accurate record of the student's address after graduation.
6. District 2 Student Branch *News Letter.*

There was an interested and active discussion of the items on the agenda, the highlights of which were reported by a representative from the Student Branch to the joint Student-counselor conference held on Friday afternoon.

The subjects presented at the conference of Student Branch counselors, the highlights of which also were reported to the joint Student-counselor conference, included:

1. What constitutes a good counselor.
2. Discussion of Student Branch and District prize paper competition for Student members under the new Institute prize competition rules, which became effective January 1, 1948.
3. Membership activity.
4. Discussion of Section-Branch co-operation.
5. Other Branch activities.
6. Election of chairman for 1948–49 District committee on Student activities.
7. Organization of local engineering student councils in each school.
8. Relative merits of the various engineering societies and how this issue shall be met by AIEE.
9. Affiliations with other societies.
10. How to get more men in power where there are more jobs.
11. Student conventions.
12. The graduate student in AIEE.
13. How the smaller Branch can engage in all Student activities.
14. Requirements for a new AIEE Branch.

Professor K. F. Sibila of the University of

**AIEE Middle Eastern District committee on Student Activities in front of Packard laboratory, Lehigh University, Bethlehem, Pa., during the meeting of the committee on November 5**

Akron was elected chairman of the 1948–49 District committee on Student activities, and it was decided that the meeting of this committee would be held next year at the University of Akron, Akron, Ohio. The committee also decided that the District Branch paper prize competition would be held at Carnegie Institute of Technology, Pittsburgh, Pa., not later than May 1, 1949.

At the joint Student-counselor conference on Friday afternoon, Doctor Whitaker, president of Lehigh University, welcomed the counselors and Student Branch chairmen to Lehigh University. The following topics were included on the agenda:

1. Messages from H. N. Muller, chairman of the Institute committee on Student Branches, and from G. W. Bower, vice-president, District 2.
2. Student Branch and District prize paper competitions for Student Members.
3. Plan of Section-Branch co-operation.
4. Membership activities.
5. How to get greater co-operation of the Student in Branch activity.
6. How to get greater co-operation by the Section and Section members in Branch activity.
7. How the smaller Branch can engage in all Student activities.
8. Transfer of Student Members to Associates upon graduation.

On Saturday morning, a 3-hour inspection trip was made of the Bethlehem Steel Company's plant which was attended by 136. The trip, arranged by the Lehigh University Student Branch, included guides and a portable public address system.

**Electron Tubes Pamphlet Available.** A pamphlet comprising papers presented at the AIEE conference on electron tubes for instrumentation and industrial use, which was sponsored by the AIEE joint subcommittee on electronic instruments in Philadelphia, Pa., March 29–30, 1948, has been prepared and is available from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. The price of the booklet, "Electron Tubes for Instrumentation and Industrial Use," is $3; $1.50 to AIEE members.

**Attending the organization meeting of the newly formed Lima (Ohio) Subsection are shown, front row, left to right: C. C. Shutt, division manager, Lima Westinghouse Electric Corporation; W. R. Appleman, chairman, Dayton Section; L. C. Schaefer, chairman, Lima Subsection; T. J. Martin, secretary, Institute Sections committee; C. E. Higgins, Dayton Section program committee; J. C. Strasbourger, chairman, Institute Sections committee. Second row, left to right: B. O. Austin, director, Lima Subsection; C. G. Veinott, vice-chairman, Dayton Section; B. F. Wyandt, first vice-president Maumee Valley chapter, Ohio Society of Professional Engineers; F. C. Horn, vice-chairman, Lima Subsection; O. M. Swain, secretary-treasurer, Lima Subsection; W. A. Dynes, past chairman, Dayton Section; L. H. Fox, past secretary, Dayton Section; F. S. Himebrook, past chairman, Dayton Section**

## Newly Formed Lima Subsection Holds Meeting, Elects Officers

L. C. Schaefer, Lima, Ohio, Westinghouse Electric Corporation engineer, was elected the first chairman of the Lima Subsection (Dayton Section) of the AIEE at a meeting of AIEE members held in the Ohio Power Auditorium, Lima, November 15, 1948. Mr. Schaefer was graduated from Purdue University in 1938, and since that time, has been associated with the Lima division of the Westinghouse Electric Corporation, except for four years' Army service with the Signal Corps. Other officers elected to this newly formed Subsection of the Dayton Section were: F. C. Horn, Lima Electric Motors, *vice-chairman;* O. M. Swain, Westinghouse Electric Corporation, *secretary-treasurer;* O. R. Jacobs, Lima Electric Products, *assistant secretary-treasurer;* B. O. Austin, Sr., Westinghouse Electric Corporation, and W. R. Ankrom, Ohio Power, *directors.*

The Lima Subsection is the first Lima group ever organized by a national engineering society. The Subsection will bring many benefits to engineers in the Lima area by providing a medium for the exchange of ideas and problems involving the members of the profession. It further will serve to bring national recognition on engineering matters to the community which it represents.

C. G. Veinott, vice-chairman of the Dayton Section, and O. M. Swain, both with the Westinghouse Electric Corporation, acted as chairman and secretary pro tem at the organization meeting.

C. C. Shutt, division manager of the Lima plant of the Westinghouse Electric Corporation, delivered the main address of the evening to 54 engineers from the Lima, Dayton, Bluffton, Ada, St. Marys, Sidney, and Cleveland area. Mr. Shutt emphasized that an objective for this organization should be the continuous promotion of the private enterprise system as the only one under which the engineering profession can continue to grow and prosper.

Among the AIEE members participating were J. C. Strasbourger, and T. J. Martin, Cleveland, chairman and secretary, respectively, of the Sections committee of the Institute; W. R. Appleman, chairman, W. A. Dynes, F. S. Himebrook, L. H. Fox and C. E. Higgins of the Dayton Section were also in attendance. Attending from the Ohio Northern University Student Branch were Francis J. Kelly, Jr., chairman, and Carl L. Powers, vice-chairman.

Burt F. Wyandt, first vice-president of the Maumee Valley chapter of the Ohio Society of Professional Engineers, W. R. Appleman, chairman of the Dayton Section, and J. C. Strasbourger extended a welcome to the group. The newly elected officers later were installed by W. R. Appleman.

## New York Section Hears Address by President Lee

AIEE President Everett S. Lee spoke to the New York Section on December 8, 1948. He recounted the recent trips made by him from the State of Washington to Florida in order to visit many Sections and attend various meetings of the Institute. President Lee spoke of the many grand receptions he received and of the good friendships he found everywhere, upon which the strength of the Institute is based. He said, "It is an inspiring picture to see the activities of the Sections." He reported that there were now 83 Sections, 40 Subsections, and 127 Student Branches of the AIEE, and described in particular the enthusiasm he found at the two most recently formed Sections, the 82d one at Richland, Wash., and the 83d one at Niagara Falls, which combined the American and Canadian Subsections.

President Lee told of some of the outstanding modern-day developments he had seen while on his trips and stated that engineers were in back of all of these—that wherever they are they make things possible. But even though the engineer holds an important place in the over-all picture of progress, he believes it necessary, if the engineers as a group wish to receive the same recognition given other professions and to which they are entitled, that they tell people of their activities and of their important contributions to world progress.

He advised that engineers must do other things besides engineering; they must learn to live with their fellowmen for happiness. Each should take an active part in the affairs of his community and bring whatever contribution he can for its betterment. Each engineer has the opportunity in his own life to receive the recognition which he deserves, and the advice to young engineers was not to stop and wait for such an opportunity but to

live on and the opportunity will come to them.

President Lee praised the organization for its strength, friendships, and the opportunity it gave to engineers to live both for themselves and their fellowmen. He said that the affairs of the Institute were in good shape and in good working order; and that the necessary adjustments have been made so that this years budget will be balanced without raising the yearly dues of the members. At the close of the meeting, President Lee discussed several questions which had been raised regarding collective bargaining, engineering unions, and the functions of the Joint Engineering Council.

The meeting was presided over by Chairman R. T. Oldfield. A colored movie, "Air Power Is Peace Power," was shown which gave the most recent developments and the plans for future development of the air transport airplanes.

On the previous evening, President Lee had addressed more than 200 electrical engineering students representing ten Student Branches in the metropolitan area.

# PERSONAL NOTES.......

**W. F. Davidson** (A '14, F '26), research engineer, Consolidated Edison Company of New York (N.Y.), Inc., has received the Presidential Certificate of Merit for his services as deputy executive officer of the National Defense Research Committee, Office of Scientific Research and Development, during World War II. Davidson has been with the company since 1922 when he joined the Brooklyn Edison company as director of engineering. He has been on the following AIEE committees: research, 1925, 1937–41 (chairman 1939–41); basic sciences, 1927–42 (chairman, 1934–36); technical program, 1934–36, 1939–40; award of Institute prizes, 1939–41; Fortescue Fellowship, 1939, 1941, 1944; nucleonics, 1947–49.

**H. C. Forbes** (A '25, F '44), vice-president, Consolidated Edison Company of New York (N.Y.), Inc., has been elected to that company's board of trustees and to its executive committee. Forbes joined the New York Edison Company in 1924 as assistant to the chief electrical engineer, and was promoted to system engineer in 1932. He was elected a vice-president in 1945, and is also vice-president of the New York Steam Corporation. **H. R. Searing** (A '20, F '30), executive vice-president of the same company, has been announced as the new chairman of the Consolidated Telegraph and Electrical Subway Company.

**K. C. DeWalt** (M '46) and **E. F. Peterson** (A '33, M '45) have been named assistant managers of the newly formed industrial and transmitting tube division of the electronics department, General Electric Company, Syracuse, N.Y. DeWalt will be responsible for all design engineering and manufacturing activities related to cathode-ray-tube product lines. Peterson will have the same responsibilities for the receiving tube product lines. **O. W. Pike** (A '30, M '36) will be the new manager of engineering, tube division, for the same department. He is on the AIEE electronics committee for 1947–49.

**E. W. Dillard** (A '16, M '30), director and electrical engineer for the New England Power Service Company, Boston, Mass., has been appointed chief engineer for that company. He has been with the New England power system since 1916. Chairman of the engineering division general committee of the Edison Electric Institute, Dillard is also on the AIEE transmission and distribution committee. He will be replaced as electrical engineer by **H. R. Stewart** (A '26, M '39), formerly protection engineer, a position he has held since 1934. Stewart's assistant will be **Harris Barber** (A '30) who has been electrical design engineer for the New England power group since 1934.

**C. H. Weaver** (A '37), former manager, marine department, Westinghouse Electric Corporation, Pittsburgh, Pa., has been named manager of the newly formed atomic power division of that company. This new division will concentrate solely on the harnassing of nuclear energy for the production of useful power. A graduate of the University of Pennsylvania in 1936, Weaver has been with Westinghouse since that year. He holds memberships in the following societies: Society of Naval Architects and Marine Engineers, American Society of Naval Engineers, Engineers Society of Western Pennsylvania.

**V. K. Zworykin** (M '22, F '45), vice-president and technical consultant, laboratories division, Radio Corporation of America, Princeton, N.J., has received the Chevalier Cross of the French Legion of Honor for his contributions to the field of television. Recommendation for the decoration was made by the French Broadcasting Society and coincided with the 25th anniversary of Doctor Zworykin's invention of the iconoscope, television's first electronic eye. A member of the AIEE communications committee, 1937–41, and the research committee, 1941–46, Doctor Zworykin also holds membership in the American Association for the Advancement of Science, the American Physical Society, the Institute of Radio Engineers, American Academy of Arts and Sciences, the French Academy of Sciences, and Sigma Xi fraternity.

**W. W. Kuyper** (A '34) has been appointed divisions engineer of the turbine, generator and gear engineering divisions at the General Electric Company's Lynn, Mass., plant. A graduate of the University of Michigan, Kuyper joined the company's "test" training program in 1933, and since then has been associated with the generator and aircraft gas turbine divisions. As a member of the engineering general staff at the General Electric Company's Schenectady, N.Y., works, he was active in the development of turbines, locomotives, and gas turbines for aircraft. Kuyper is also a member of The American Society of Mechanical Engineers and the Society of Naval Architects and Marine Engineers.

**M. M. Peterson** (A '29, M '42), former design engineer, United States Bureau of Reclamation, has been appointed associate professor of electrical engineering at West Virginia University, Morgantown, W. Va. A 1927 graduate of Ohio Northern University, Peterson has been engaged in high-voltage research work since 1931. In 1943, he was appointed assistant professor at the high-voltage laboratory of Cornell University. He is a member of the American Society for Engineering Education, the National Research Council, and the American Association for the Advancement of Science.

**J. G. Pleasants** (A '48), director of manufacture, Proctor and Gamble Company, Cincinnati, Ohio, has been made vice-president in charge of manufacture. He joined the company in 1933 and was advanced through various technical departments to become plant superintendent at both the New York, N.Y., and Baltimore, Md., plants of the firm. In 1946, Pleasants was named division superintendent at the Cincinnati plant and shortly thereafter was made director of technical divisions. In 1947 he became director of manufacture, the position he held until his recent promotion.

**C. S. Lumley** (A '23, F '45) has been appointed executive vice-president and director of engineering of the H. E. Beyster Corporation, Architects and Engineers, Detroit, Mich. He also will serve on the board of directors and the corporation's executive committee. Lumley was formerly power and industrial division manager and chief engineer for Smith, Hinchman and Grylls, Inc., Engineers and Architects, of Detroit, and New York, N.Y. During World War II, he was in complete administrative charge of an industrial engineering project of the United States Navy for that company.

**D. D. Pittman** (M '47), former district manager, Locke Insulator Corporation, Chicago, Ill., has been appointed sales representative in the states of Wisconsin, Minnesota, Iowa, and the northern peninsula of Michigan for the Illinois Electric Porcelain Company, Macomb. He has had many years experience in all phases of porcelain application.

**R. L. Westbee** (A '36), formerly electrical tape sales chief, Minnesota Mining and Manufacturing Company, St. Paul, has been appointed to head production and distribution of that company's electrical and sound recording tapes.

**J. W. Butler** (A '31, F '46), transformer division, General Electric Company, Pittsfield, Mass., has been named manager of the commercial engineering divisions of the company's transformer and allied products divisions.

**H. F. Smiddy** (A '22), now general manager of the chemical department of the General Electric Company, also will become general manager of the company's air conditioning department effective November 1, 1948. Formerly a partner in Booz, Allen and Hamilton, industrial management consultants, New York, N. Y., Smiddy also has been a director of Ebasco Services, Inc., and an executive of the Electric Bond and Share Company.

**R. C. Muir** (A '08, F '36) will retire as general manager of the General Electric Company's nucleonics department, Schenectady, N. Y., effective January 1, 1949, but will continue as consultant for the company. Active in AIEE, Muir has been on the following AIEE committees: protective devices, 1927–30; planning and co-ordination, 1939–42; Institute policy, 1940–42; education, 1932–33; Member-for-Life Fund, 1944–46.

**L. W. Clark** (A '25, M '42), former assistant superintendent, has been named superintendent of underground lines for the Detroit (Mich.) Edison Company. Clark was chairman of the AIEE electric welding committee in 1944–45, and a member of that committee from 1938 to 1945. He also has served on the industrial power applications (1942–45), Standards (1944–45), and technical program (1944–45) AIEE committees.

**D. A. Quarles** (A '23, F '41), vice-president of the Bell Telephone Laboratories, Inc., New York, N. Y., has been named to the finance committee of the United Engineering Trustees, Inc. Quarles is a director of AIEE for 1944–48 and on the board of trustees for 1945–48. He also has been a member of the AIEE committees on finance, 1944–46; Edison Medal, 1945–47; electronics, 1945–47; instruments and measurements, 1945–46.

**F. L. Lawton** (A '25, M '36), formerly assistant chief engineer, Aluminum Company of Canada, Limited, Montreal, Quebec, has been appointed head of the newly formed power department of Aluminum Laboratories Limited. Among the AIEE committees Lawton has served on are: Sections, 1945–47; electrochemistry and electrometallurgy, 1945–48; power generation, 1946–49; chemical, electrochemical, and electrothermal applications, 1945–48.

**Thomas Shaw** (M '14), loading transmission department, Bell Telephone Laboratories, Inc., New York, N.Y., has retired. He has been with the company since he was 17 years of age, and during that time has been graduated from the Massachusetts Institute of Technology, has published numerous technical papers, and has taken out 21 patents concerned with telephony. He has been doing development work on loading and circuits since 1914.

**R. Whitehurst** (A '20, F '43), sales manager since 1944 for the Electric Storage Battery Company, Philadelphia, Pa., has been elected vice-president in charge of sales. He has been with the company for 40 years.

**F. P. Barnes** (A '43, M '45) has been appointed sales manager of broadcast equipment for the transmitter division at the General Electric Company's Electronics Park, Syracuse, N.Y. Barnes joined the General Electric Company's engineering test course in 1937 and has specialized in industrial electronics and radio communications for that company on the West Coast. He also has instructed in these subjects at the University of Washington, Seattle. Barnes is a member of the Institute of Radio Engineers.

**A. C. Monteith** (A '25, F '45), vice-president in charge of engineering and research, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the honorary degree of doctor of laws by his alma mater, Queens University, Kingston, Ontario, Canada. A 1923 graduate of that school, Monteith joined the Westinghouse company in that year and since has risen through the engineering ranks to his present position as vice-president. At present, Doctor Monteith is a director of AIEE.

**T. F. Madden** (A '47), an employee of the Allis-Chalmers Manufacturing Company's Pittsburgh, Pa., works will study for a doctor of science degree in mathematics and electrical engineering at the University of Pittsburgh under a graduate fellowship awarded him by the Allis-Chalmers company. He will make a special study of vibrations caused by expansion and contraction of metal in transformer cores due to high voltage impressed on them. Madden received his bachelor of science and his master of science degrees from Cornell University and Carnegie Institute of Technology respectively.

**W. E. Ross** (M '38), formerly manager of the apparatus sales department, Canadian General Electric Company, Toronto, Ontario, Canada, has been named as assistant to the president of that company. A native of England, he has been with the company since 1919. He will be succeeded as manager of the apparatus sales department by **A. M. Doyle** (A '37, M '44) who was formerly apparatus division manager in the company's Toronto district office. Doyle has been with Canadian General Electric since his graduation from the University of Manitoba in 1928.

**R. E. Murphy** (A '42), former vice-president in charge of sales, I-T-E Circuit Breaker Company, Philadelphia, Pa., and member of the board of directors of the Railway and Industrial Engineering Company, Greensburg, Pa., has been elected to the board of governors of the National Electrical Manufacturers Association. Elected vice-president for 1949 for that organization was **C. W. Higbee** (M '37), manager, wire and cable department, United States Rubber Company, New York, N.Y.

**G. A. Menard** (A '43), formerly in charge of sales of power switching equipment and switchgear components, General Electric Company, Philadelphia, Pa., has been named vice-president and general manager of the Memco Engineering and Manufacturing Company, Inc., Woodside, N. Y.

**H. H. Gnuse** (A '34, M '46) has been appointed vice-president in charge of engineering for the Nantahala Power and Light Company, Franklin, N.C. He joined that firm as assistant electrical engineer in 1940, and was made electrical engineer in charge of operation and maintenance of the generation and distribution systems in 1942.

**P. H. Goodell** (A '40, M '46) has been appointed manager of industrial heating sales for the Trumbull Electric Manufacturing Company, Plainville, Conn. He is a pioneer in electric infrared heating and is serving on the AIEE electric heating committee for 1947–49. He is also a member of the Illuminating Engineering Society.

**R. P. O'Brien** (A '45) has been appointed supervising engineer for the California Public Utilities Commission and will be responsible for specific special departmental assignments. He will be succeeded by **L. R. Knerr** (A '31, M '37) as electrical engineer in charge of activities of the electric division.

**G. W. Penney** (A '26, F '45), George Westinghouse professor of electrical engineering, Carnegie Institute of Technology, Pittsburgh, Pa., is the chairman of the AIEE electronic precipitation subcommittee.

**A. Coggeshall** (A '05), formerly president of Hatzel and Buehler, Inc., New York, N.Y., has joined the newly formed New York (N.Y.) Maintenance Corporation, and will serve as that organization's president. Purpose of the company will be to furnish electric maintenance and repair service for industrial plants and commercial buildings in the New York metropolitan area.

**J. A. Robinson** (A '43), has been appointed Pacific Coast editor of *Electrical World* magazine. He has been on the staff of the magazine for the past year after leaving the San Francisco, Calif., office of the General Electric Company where he was employed in the industrial division of the apparatus department. He had been with that company since his graduation from the University of California in 1942.

**D. B. Sinclair** (M '45), assistant chief engineer, General Radio Company, Cambridge, Mass., has been awarded the Presidential Certificate of Merit for outstanding service during World War II in the countermeasures and guided missile divisions of the National Defense Research Council. Sinclair is a member of the AIEE committee on instruments and measurements for the 1948–49 year.

## OBITUARY • • • •

**Aldred K. Warren** (A '95, M '13), pioneer in the electrical engineering field, died November 20, 1948. He was born in 1866 at Somersetshire, England, and received his

technical training at Kings College, London, England, graduating in 1885. From 1886 to 1889, Warren was employed by the Canadian Pacific Railway, and then for three years he was a member of the Edison Pioneers, a group that worked in close association with the late Thomas A. Edison at the Edison General Electric Company. In 1893 he established his own consulting electrical engineering office in New York, N.Y., but closed it in 1900 to become superintendent and electrical engineer with the old Brooklyn Rapid Transit and Interborough Rapid Transit companies. Between 1903 and 1908, he was general manager and chief engineer of the American Automatic Switch Company, installing the automatic switch he invented in the New York City streetcar system. He then joined the International General Electric Company, the firm he was with until his retirement in 1931. His last assignment for that company was the reorganization, building, and equipping of the Shibaura Engineering Works in Japan. He was a Member for Life of the Institute.

**Clare W. Colvin** (A '12, M '37), engineer with the British Columbia Electric Railway Company and assistant to the vice-president, died October 9, 1948. He was born September 24, 1886, in Galt, Ontario, Canada. He was a graduate of the University of Toronto, Canada, in 1907. From 1906 to 1909, he did considerable work on the construction and installation of industrial plants, steel and cement mills, distilleries, grain elevators, and packing houses. For the next two years, Colvin was chief electrical designer in charge of designs and specifications for the firm of Smith, Kerry, and Chace, and from 1912 to 1919, did electrical designing work for various companies in British Columbia. In 1919, he became assistant appraiser and chief engineer for the British Columbia Electric Railway Company. From 1921 until 1925 he did much of that company's electrical designing and in 1925, was transferred to their construction division. In the years that followed, Colvin became appraisal engineer and, later, head of the electrical section of the construction department. In 1941, he was made superintendent of the engineering division, and he was advanced to chief engineer and assistant to the vice-president in 1946.

**James Hugh Smeaton** (A '07), retired electrical engineer, formerly with Brazilian utilities, died October 30, 1948. Born in the Province of Quebec, Canada, he was graduated from the Collegiate Institute, Niagara Falls, Ontario, Canada, in 1896. From 1898 to 1902, Smeaton was with the Canadian Pacific Railway in their mechanical department. He then joined the West Kootenay Power Company in British Columbia and rose to be chief operator before leaving in 1905 to become superintendent in charge of installation of high-tension wiring for the Winnipeg Electric Railway Company, Manitoba. He later worked for the Pennsylvania Power Company, but in 1911 accepted an appointment with the São Paulo Light and Power Company of Brazil. Smeaton served a total of 34 years between this company and the Rio de Janeiro Tramway Light and Power Company, Rio de Janeiro, Brazil. He held the position of electrical superintendent for this latter company until his retirement in 1945. He was a Member for Life of the Institute.

**Selby Haar** (A '07, M '13), former electrical engineer, Board of Transportation, New York, N.Y., died September 5, 1948. He was born November 24, 1881, in Kansas City, Mo., and was graduated from the Massachusetts Institute of Technology in 1904. From that year until 1912, Haar did electrical and mechanical design work for the General Electric Company, Schenectady, N.Y. Between 1912 and 1916, he was employed by various large electrical manufacturing concerns designing power plants, substations, and high- and low-tension distributing systems. In 1916, he became an assistant electrical engineer with the Public Service Commission, checking designs and inspecting equipment in New York City's dual rapid transit system. At the time of his death, Haar was electrical engineer in the New York City Board of Transportation equipment and operation department. He was a member of the AIEE traction and transportation committee in 1921–22 and the AIEE land transportation committee from 1936 to 1942.

**Ford H. Dubs** (A '27), system planning engineer, Toledo (Ohio) Edison Company, died recently. Born in Decatur, Ill., on July 7, 1893, he was a graduate electrical engineer of the University of Arkansas. In 1917, he was power plant construction engineer for the Fremont Gas and Electric Company, Fremont, Nebr., and in 1918, did substation installations for the Hattisburg Traction Company, Hattisburg, Miss. For the next two years, Dubs did engineering work on the design and reconstruction of distribution systems and the construction of transmission lines in various parts of Ohio. He became general superintendent in charge of hydroelectric and steam generating stations for both the Bristol Gas and Electric Company and the Watunga Power Company of Tennessee in 1921, and joined the Toledo Edison Company in 1924 as a distribution and transmission system researcher in the engineering department. Dubs became assistant system operator in 1924 and was advanced to the position he held at his death, that of system planning engineer.

**Alvin G. Becker** (A '47), founder, president, and manager of the Round Valley Light and Power Company, Springerville, Ariz., died October 18, 1948. He was born in Springerville on September 27, 1894, and took his technical training at the University of California, Berkeley, until entering the United States Army in World War I. From 1919 until 1927, Becker surveyed sites and conducted a careful study of hydroelectric plant possibilities for the area surrounding his home town. In that latter year, he had a dam, canal, hydroelectric plant, and transmission system built. He personally did all the planning, engineering, supervision, and operation of the company he had created and called the Round Valley Light and Power Company.

# MEMBERSHIP ....

## Recommended for Transfer

The board of examiners at its meeting of November 18, 1948, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

### To Grade of Fellow

Beekman, R. A., mgr. federal & marine engg. div., General Elec. Co., Schenectady, N. Y.
Dorfman, L. O., electrical design supervisor, Ebasco Services, Inc., New York, N. Y.
Joy, H. M., director of engg., The Master Elec. Co., Dayton, Ohio.
Shackelford, B. E., RCA International Division, New York, N. Y.

4 to grade of Fellow

### To Grade of Member

Anderson, R. E., asst. prof. of elec. engg., University of New Hampshire, Durham, N. H.
Beckett, J. C., chief engr., Wesix Electric Heater Co., San Francisco, Calif.
Cronvich, J. A., assoc. prof. of elec. engg. & biophysics, Tulane Univ., New Orleans, La.
Dorey, F. M., application engr., General Elec. Co., Los Angeles, Calif.
Fellers, R. G., physicist, U. S. Naval Research Lab., Washington, D. C.
Forrester, J. W., assoc. director, servomechanisms lab., Massachusetts Institute of Tech., Cambridge, Mass.
Ginn, W. S., mgr., power transformer sales div., General Elec. Co., Pittsfield, Mass.
Hildebrandt, J. P., vice-pres. & genl. mgr., instrument service div., Houston Slush Pump Repair Co., Inc., Houston, Tex.
Jankiewicz, E. J., elec. engr., naval air experimental station, U. S. Naval Base Station, Phila., Pa.
Johnson, M. R., Jr., asst. prof. elec. engg. dept., Louisiana Polytechnic Inst., Ruston, La.
LeVino, R. B., chief, televisual equipment section, Coles Signal Laboratory, Red Bank, N. J.
McGrath, M. H., asst. chief engr., General Cable Corp., New York, N. Y.
Oden, C. M., senior engr., Commonwealth Edison Co., Chicago, Ill.
Rush, P. E., assoc. prof. elec. engg., Univ. of Pittsburgh Pittsburgh, Pa.
Taylor, E. O., senior lecturer in elec. engg., University of Edinburgh, Edinburgh, Scotland.
Taylor, H. C., elec. supervisor, power dept., Houston Lighting & Power Co., Houston, Tex.
Treweek, J. E., relay engr., Pennsylvania Pr. & Lt. Co., Hazelton, Pa.
Webb, J. R., (Mrs.), electronics engr., research dept., The Foxboro Co., Foxboro, Mass.
Willis, R. S., div. equipment supervisor, Southwestern Bell Tel. Co., Houston, Tex.

19 to grade of Member

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before January 21, 1949, or March 21, 1949, if the applicant resides outside of the United States, Canada, or Mexico.

### To Grade of Member

Anderson, W. F., Lt. Cmdr., U. S. Naval Academy, Annapolis, Md.
Ansell, G. C., Westinghouse Elec. Corp., San Diego, Calif.
Baker, C. H., S & C Elec. Co., Chicago, Ill.
Banyas, A., Westinghouse Elec. Corp., New York, N. Y.
Bell, L. E., Univ. of Calif., Los Alamos Scientific Lab., Los Alamos, N. Mex.
Bhattacharyya, S. K., Govt. Telegraph Workshops, Alipore, Calcutta, India
Bonwitt, W. F., Burndy Engg. Co. Inc., New York, N. Y.
Clarkson, J. J., General Elec. Co., Fort Wayne, Ind.
Clewell, D. H., Magnolia Petroleum Co., Dallas, Tex.
Cole, G. H., Sr. (re-election) Armco Steel Corp., Middletown, Ohio
Deming, A. F., Hughes Aircraft Co., Culver City, Calif.
Flanagan, S. J., Brown Wood Preserving Co., Louisville, Ky.
Fleig, W. J., Wilbur J. Fleig & Assoc., Chicago, Ill.
Frisch, E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Godbold, N. H., Univ. of California, Atomic Bomb Lab., Los Alamos, N. Mex.
Grimshaw, H. R., T.V.A., Chattanooga, Tenn.
Henshaw, M. D., General Elec. Co., Erie, Pa.
Heye, B. F., Central Power & Light Co., Corpus Christi, Tex.
Hickson, W. A., N. Y. Tel. Co., Brooklyn, N. Y.
Hinkley, J. W., III, Research Corp., New York, N. Y.
Hoffmann, D. C., General Elec. Co., Philadelphia, Pa.
Howe, W. A., Westinghouse Elec. Corp., San Francisco, Calif.
Howell, C. H., Federal Power Comm., Washington, D. C.

Johnson, G. H., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Jones, W. R., Cornell Univ., Ithaca, N. Y.
Keilien, S., Pass & Seymour, Inc., Syracuse, N. Y.
Lattauzeo, A. T., Westinghouse Elec. Corp., New York, N. Y.
Lewis, W G., Allis-Chalmers Mfg. Co., Boston, Mass.
Luchini, O. J., Natl. Advisory Comm. for Aeronautics, Cleveland Airport, Cleveland, Ohio
Moss, L. B., Southern Calif. Edison Co., Los Angeles, Calif.
Newman, J. W., Vyne Bros. Elec. Co., Prescott, Ariz.
Price, E. F., Ministry of Civil Aviation, London, England
Puppikofer, H. W., Ateliers de Construction Oerlikon, Zurich, Switzerland
Raymond, R. E., Florida Power Corp., St. Petersburg, Fla.
Richard, T. E., Aeroproducts Div. of G.M.C., Dayton, Ohio
Robertson, W. D., Austin Co., New York, N. Y.
Roland, S. W., Federal Power Comm., Washington, D. C.
Scott, H. L., H. L. Scott Electrical Eng. & Construction, Corpus Christi, Tex.
Sinclair, A. B., Price Bros. & Co., Ltd., Kenogami, Quebec, Canada
Smith, C. L., National Fire Protection Ass'n., Chicago, Ill.
Stantial, M. T., Stone & Webster Engg. Corp., Boston, Mass.
Villavaso, J. M., Louisiana Power & Light Co., New Orleans, La.
Volkmer, T. F., General Elec. Co., Pittsfield, Mass.
Watson, D. L., Anglo Iranian Oil Co., London, England
Watts, W. E., Wisconsin Tel. Co., Milwaukee, Wis.
Welch, N. H., Kansas City Power & Light Co., Kansas City, Mo.
Wilder, W. S., Wisconsin Elec. Power Co., Milwaukee, Wis.
Wise, A. G., Master Elec. Co., Dayton, Ohio
Wyandt, B. F., Lima Elec. Motor Co., Lima, Ohio

49 to grade of Member

## To Grade of Associate

**United States and Canada**

1. North Eastern

Bigelow, J. E., General Elec. Co., Schenectady, N. Y.
Crabb, M. W., Link Aviation, Inc., Binghamton, N. Y.
Domke, D. R., Jr., H. Henry Anthony Power Utilities, Boston, Mass.
Ebrite, S., General Elec. Co., Pittsfield, Mass.
Gauper, H. A., Jr., General Elec. Co., Schenectady, N. Y.
Lee, T. H., General Elec. Co., Schenectady, N. Y.
Lewkowicz, T. B., General Elec. Co., Schenectady, N. Y.
Lueders, C. J., General Elec., West Lynn, Mass.
Lundy, R. T., General Elec. Co., Schenectady, N. Y.
Newman, F. W. (re-election), General Elec. Co., West Lynn, Mass.
Raunick, D. A., Stromberg Carlson Co., Rochester, N. Y.
Rosson, J. L., Cornell Univ., Ithaca, N. Y.
Scanlan, E. J., General Elec. Co., Schenectady, N. Y.
Scott, J. L., Jr., Hubbard & Co., Binghamton, N. Y.
Stanton, W. M., General Elec. Co., Schenectady, N. Y.
Stantz, L. H., Radio Station *WNBF* & *WNBF-FM*, Binghamton, N. Y.
Ward, C. H., Jr., General Elec. Co., Schenectady, N. Y.
Yates, E. A., General Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Alexander, M. F., The Cleveland Elec. Illuminating Co., Cleveland, Ohio
Bell, R. N., Westinghouse Elec. Co., E. Pittsburgh, Pa.
Chervenko, S. R., Osborn Engg. Co., Cleveland, Ohio
Chyba, H. J. (re-election) Industrial Research Laboratories, Baltimore, Md.
Clayton, J. M., Jr., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Clow, G. V., The National Cash Register Co., Dayton, Ohio
Conley, C. W., Leece Neville Co., Cleveland, Ohio
Crowe, I. E., Northern Pennsylvania Power Co., Towanda, Pa.
Czapor, E. P., Delco Products Co., Dayton, Ohio
Diamantides, N. D., Leece Neville Co., Cleveland, Ohio
Donato, A. V., Bethlehem Steel Co., Baltimore, Md.
Donato, G., Ercole Marelli & C. S. p. A., Milan, Italy, c/o Westinghouse Elec. Co., E. Pittsburgh, Pa.
Elder, R. W., General Elec. Co., Toledo, Ohio
Feil, C. W., The Ohio Power Co., Ironton, Ohio
Fillingame, H. F., American Tel. & Tel. Co., Philadelphia, Pa.
Fried, E., The Wolfe & Mann Mfg. Co., Baltimore, Md.
Garrett, H., W. V. Pangborn Co., Norristown, Pa.
Gleichauf, P. H., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Green, R. R., Lt. Comdr., U.S.N., Johns Hopkins Univ. School of Engg., Baltimore, Md.
Hawkes, L. C., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Hoffman, H. T., Jr., Bailey Meter Co., Cleveland, Ohio
Irby, J. W., Wright-Patterson AF Base, Dayton, Ohio
Kerschensteiner, J. M., Glenn L. Martin, Baltimore, Md.
Kershaw, W. L., The Glenn L. Martin Co., Middle River, Md.
Luh, M. D., The Glenn L. Martin Co., Middle River, Md.
McCoy, E. K. (re-election) Ohio Bell Tel. Co., Dayton, Ohio
McWhirter, J. H., Westinghouse Elec. Corp., Mercer, Pa.
Miller, D. J., Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio
Nielson, J. W., Delco Products Div., G.M.C., Dayton, Ohio
Nix, R. J., Rochester & Pittsburgh Coal Co., Indiana, Pa.
Parassio, A. V., General Elec. Co., Philadelphia, Pa.
Parker, E. L., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Renas, L. J., Dayton Power & Light Co., Dayton, Ohio
Ross, M., Philadelphia Elec. Co., Philadelphia, Pa.
Schwartz, C. A., National Tube Co., Lorain, Ohio
Sernel, F., Lake Shore Elec., Cleveland, Ohio
Simpson, R. H., Timken Roller Bearing Co., Canton, Ohio
Smith, L. B., Bethlehem Steel Co., Baltimore, Md.
Smith, R. H., Hoover Co., North Canton, Ohio
Spira, L., Lake Shore Elec. Mfg. Corp., Cleveland, Ohio
Stallings, H. L., Glenn L. Martin Co., Baltimore, Md.
Stockstill, W. L., Delco Products Div., G.M.C., Dayton, Ohio
Stratis, L. J., 2411 Clifton Ave., Cincinnati, Ohio.
Swango, L. H., Delco Products Div., G.M.C., Dayton, Ohio
Thornberry, P. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Walker, J. H., Jr., Public Service Supply Co., Inc., Cleveland, Ohio
Walter, J. F., Philadelphia Elec. Co., Philadelphia, Pa.
Wilburn, J. E., The Glenn L. Martin Co., Middle River, Md.

3. New York City

Angehrn, J., Lummus Co., New York, N. Y.
Bartholomew, J. F., Westinghouse Elec. Corp., Newark, N. J.
Bradervalt, J. A., City of Paterson, Paterson, N. J.
Brodie, A. C., Mediterranean Refining Co., New York, N. Y.
Celander, F. J., Westchester Lighting Co., White Plains, N. Y.
Dickey, F. B., Anaconda Wire & Cable Co., New York, N. Y.
Dow, L. J., Allstates Engg. Co., Trenton, N. J., c/o I. B. M. Corp., Poughkeepsie, N. Y.
Gershfield, M., M. W. Kellogg Co., New York, N. Y.
Giles, W. J., Devenco, New York, N. Y.
Gould, J. B., Consolidated Edison Co., Brooklyn, N. Y.
Kletecka, B. W., Consolidated Edison Co., Brooklyn, N. Y.
Lader, N., Syska & Hennessy, Inc., New York, N. Y.
Lawson, A. H., Burns & Roe, Inc., New York, N. Y.
Morgan, R. B., Pratt Institute, Brooklyn, N. Y.
Peck, M. C., Rockland Light & Power Co., Middletown, N. Y.
Rawls, F., Western Elec. Co., New York, N. Y.
Schmitzer, J. H., Devenco, Inc., New York, N. Y.
Shapiro, H. B., Lummus Co., New York, N. Y.
Steinbrucker, F. G., Consolidated Edison Co., New York, N. Y.
Stemp, F. C., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Terry, W. W., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Van Gendt, G. J., Lindeteves, Inc., New York, N. Y.
Veit, V. A., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Vrana, N. M., American District Tel. Co., New York, N. Y.
Wichman, W. T., Bell Tel. Labs., Inc., New York, N. Y.
Williams, J. T. (re-election), Rockbestos Prod. Corp., New York, N. Y.
Zito, F. A., Electrical Testing Labs., Inc., New York, N. Y.

4. Southern

Bell, B. H., Jr., Louisiana Power & Light Co., Gretna, La.
Belter, O. C., T. V. A., Watts Bar Dam, Tenn.
Bennett, J. H., Westinghouse Elec. Corp., Jackson, Miss.
Blackwell, W. E., The Citadel, Charleston, S. C.
Carden, O. R., Sr., Tampa Armature Works, Inc., Tampa, Fla.
Carter, R. W., Alabama Power Co., Birmingham, Ala.
Clayton, D. B., Sr., Elec. Constructors, Inc., Birmingham, Ala.
Cotton, A. F. R., Melpar, Inc., Alexandria, Va.
Finch, V. C., Jr., Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Dale, F. L., Georgia Power Co., Atlanta, Ga.
Hawkins, N. H., Jr., Birmingham Elec. Co., Birmingham, Ala.
Holmes, T. W., Florida Power & Light Co., Miami, Fla.
Lusk, J. H., Todd-Johnson Dry Docks Inc., New Orleans, La.
Minor, A. F., Southern Bell Tel. & Tel. Co., Jackson, Miss.
Moody, R. E., Kinsley McWhorter & Assocs., Staunton, Va.
Mullen, D. H., Westinghouse Elec. Corp., Birmingham, Ala.
Pittington, E. F., Elec. Service Co., Harrisonburg, Va.
Sockwell, H. M., Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Storie, R. E., T. V. A., Knoxville, Tenn.

5. Great Lakes

Cooper, M., Public Service Co. of Northern Illinois, Chicago, Ill.
Ethier, T. J., Louis-Allis Mfg. Co., Milwaukee, Wis.
Haeger, A. J. (re-election) Graybar Elec. Co., Chicago, Ill.
Jones, D. T., Copperweld Steel Co., Chicago, Ill.
Kenney, J. P., Public Service Co. of Northern Ill., Chicago, Ill.
King, R. M., General Elec. Co., Peoria, Ill.
Marchenko, P., Indiana & Michigan Elec. Co., Ft. Wayne, Ind.
McClalland, J. F., Stone & Webster Engg. Corp. Rockford, Ill.
Mier, D. W., Delco Battery Operations, Muncie, Ind.
Powers, K. J., Allis Chalmers Co., Milwaukee, Wis.
Rather, H. R., Cutler-Hammer, Inc., Milwaukee, Wis.
Sayler, J. B., The Texas Co., Lockport, Ill.
Schultz, B. H., Line Material Co., S. Milwaukee, Wis.
Seyller, J. H., Caterpillar Tractor Co., Peoria, Ill.
Shearier, E. L., Combined Locks Paper Co., Combine Locks, Wis.

6. North Central

Dye, M. M., Mountain States Tel. & Tel. Co., Denver, Colo.
Hunkins, H. D., Bureau of Reclamation, Denver, Colo.
Miller, C. L., All Automatic Action Engineers, Genoa, Colo.
Schwalm, E. E., Omaha Public Power Dist., Omaha, Nebr.

7. South West

Anglin, H. S., Harvest Queen Mill & Elevator Co., Plainview, Tex.
Chesher, T. A., Jr., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Davis, D. P., H. L. Scott, Corpus Christi, Tex.
DeNeui, M. E., Black & Veatch, Kansas City, Mo.
Duke, W. C., West Texas Utilities Co., Abilene, Tex.
Frost, S. C., Jr., Southwestern Bell Tel. Co., Dallas, Tex.
Garner, C. R., Southwestern Public Service Co., Dalhart, Tex.
Garst, C. R., J. M. Huber Corp., Borger, Tex.
Hallmark, A. C., Southwestern Public Service Co., Dalhart, Tex.
Hutchinson, R. B., Geophysical Service Inc., Dallas, Tex.
Jones, A. P., U. S. Bureau of Reclamation, Amarillo, Tex.
Lawless, E., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Medlin, H. L., Southwestern Bell Tel. Co., Dallas, Tex.
Metzenthin, J. E., Crouse Hinds Co., Dallas, Tex.
Mintz, J. M., Tide Water Associated Oil Co., Midland, Tex.
Perkins, F. S., Consolidated Vultee Aircraft Corp., Daingerfield, Tex.
Redus, H. D., Southwestern Public Service Co., Pampa, Tex.
Smith, F. H., Southwestern Public Service Co., Lubbock, Tex.
Tyler, T., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Weathersbee, C. A., H. N. Roberts & Assocs., Lubbock, Tex.

8. Pacific

Fenno, R. E., San Francisco Naval Shipyard, San Francisco, Calif.
Glenny, W. W. (re-election), C. A. Miketta, Los Angeles, Calif.
Hunt, W. S., Los Angeles Dept. Water & Power, Boulder City, Nev.
Hoxie, W. V., Pacific Gas & Elec. Co., Salinas, Calif.
Hoyt, H. E., Electrical Engg. & Mfg. Corp., Los Angeles, Calif.
Hutchinson, M. P. (Mrs.) Mare Island Navy Yard, Calif.
Long, F. L., Jr., Los Angeles Dept. Water & Power, Boulder City, Nev.
McLellan, A. F., Pacific Gas & Elec. Co., Montgomery Creek, Calif.
Smith, E. P., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Stone, J. E., N.A.C.A. (Ames Lab.), Moffett Field, Calif.
Strupp, P. J. (re-election) Salt River Valley Water User Assn., Phoenix, Ariz.
Turner, W. C., Pacific Gas & Elec. Co., Montgomery Creek, Calif.

9. North West

Corbett, H. L., Jr., Corbett, Veek & Co., Portland, Oreg.
Greer, J. H., General Elec. Co., Richland, Wash.
Hayes, R. E., Wagner Elec. Corp., Portland, Oreg.
McLaren, G. W., Allis-Chalmers Mfg. Co., Portland, Oreg.
Price, T. P., Public Utility Dist. of Pacific County, Raymond, Wash.

10. Canada

Mahon, E. G., Shawinigan Engg. Co., Ltd., Montreal, Quebec, Canada
Wilkins, H. E., Elec. & Gas Inspection Service, Hamilton, Ontario, Canada

**Elsewhere**

Bhandari, S. C., Hukumchand Mills, Naihati, West Bengal, India
Brandt, L., Mauricio Brandt's Firm, Buenos Aires, Argentina, S. A.
Ghay, D. D., Principal National Inst. of Engg., Hoshiarpur, E. Punjab, India
Olsson, A. O., Allmanna Svenska Elektriska Aktiebolaget, Ludvika, Sweden
Padmanabhan, R., Tata Iron & Steel Co. Ltd., Jamshedpur, India
Sarkar, N., College of Engg. & Technology, Bengal, India

Total to grade of Associate

United States and Canada, 170
Elsewhere, 6

# OF CURRENT INTEREST

## UN Plans Science Conference on Conservation of Resources

The Economic and Social Council of the United Nations has published a report calling for a scientific conference on the conservation and utilization of resources to be held somewhere in the United States for 15 working days during the period of May to June 1949. The conference has the support of President Truman and both the Departments of the Interior and of Agriculture.

The conference is to be scientific, rather than policy-making, and it was stated officially that "the task of the conference is to be limited to an exchange of experience on the techniques of conservation and utilization of resources." The principal aim of the conference therefore is to bring together experts from many related fields to ascertain the practical applications of science to resource management and human use, rather than with minute refinements in research and scientific methodology.

The United Nations' interest in this conference is two-fold. First, it is recognized that a lack of access to natural resources and the wasteful use of existing resources are among the principal causes leading to war. Second, the teaching of the proper techniques for the utilization and conservation of natural resources is a large-scale problem in fundamental education in science. The United Nations Educational, Scientific and Cultural Organization therefore has recommended that the conference program include the educational aspects of the problem, and that special attention be given to the training of technical and scientific personnel.

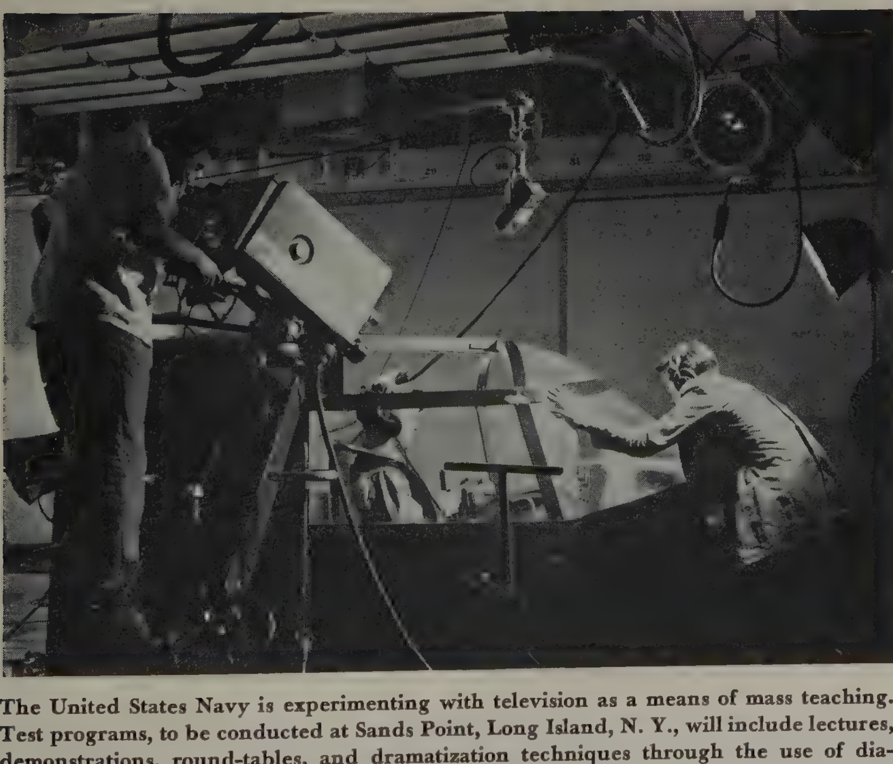
The program will consist of 18 plenary meetings, each to last half a day. The first will be devoted to a general survey of the world resources situation, with emphasis on the increasing pressure on and the depletion of resources. The following seven half-day sessions, on "Using and Conserving Resources," will stress interdependence of resources and their integrated development. Included will be sessions on soils, fuel, metals, and creatable resources, such as food and industrial raw materials, and on methods of resource appraisal and the assessment of conservation programs.

The next four sessions will deal with resource techniques of interest to less developed countries, with the final four meetings to be devoted to actual experiences in interrelated application of resource techniques and a general summary and review of all the plenary meetings.

Also on the program are 60 section meetings, to be held on 12 mornings, five sections meeting simultaneously. They will cover such general topics as forests, water, land resources, wildlife, fish and marine resources, fuel and energy, and mineral resources.

The entire conference will be conducted in the working languages of the United Nations, with the use of simultaneous interpretation. Text of papers presented to the conference, together with summaries of the discussions at the sessions, will be printed for general circulation.

## Navy Teaches Via Television



**The United States Navy is experimenting with television as a means of mass teaching. Test programs, to be conducted at Sands Point, Long Island, N. Y., will include lectures, demonstrations, round-tables, and dramatization techniques through the use of diagrams, maps, films, and models. Shown above is the method whereby a single set of instructional material may be televised for observation by large groups of students**

### Oil Supply May Increase by New Seismic Method

The Institute of Inventive Research of San Antonio, Tex., announced recently that a new method of seismic oil exploration developed by Doctor Thomas C. Poulter, eminent scientist and twice Congressional Medal of Honor winner, had reached an experimental stage where results appeared most promising. The principal advantages of the Poulter method over those currently in use are that it will eliminate the drilling of shot holes and their attendant costs, and permit greater speed in the seismic mapping of given areas. In addition, it may allow seismic exploration in areas presently not suited to it, as well as operations over water without loss of marine life.

Emphasizing that the research program had not been completed, Doctor Poulter explained that his method in one form employs a pattern of small, specially shaped charges of explosive compositions which are detonated above the ground as contrasted with conventional methods of firing a single, large charge in a shot hole at various depths beneath the surface. In discussing his method, Doctor Poulter, who is associate director of Stanford Research Institute of Palo Alto, Calif., disclosed that it usually produced the same, or in many instances better, seismic records than present procedures, and that it employed the identical seismic recording equipment now generally in use.

The new method was developed under the sponsorship of the Institute of Inventive Research, a nonprofit public service organization endowed by Tom Slick, Texas oil producer and rancher, to provide assistance for inventors. Doctor Poulter presented his plan to the institute during the summer of 1947 and the initial portion of the experimental work was carried out under an agreement between the institute and Armour Research Foundation of Chicago, whereby Doctor Poulter, at that time a member of Armour's scientific staff, conducted the research. Relating that his first work along

this line was carried out in the Antarctic while he was second in command and scientific advisor of the Byrd Antarctic Expedition of 1933–35, Doctor Poulter said the above-ground explosion method had been tested and checked against records obtained by conventional methods in both proved and unproved areas of Texas, Oklahoma, and elsewhere.

Describing his procedure, Doctor Poulter asserted the charges in the explosive pattern are set up on stakes relatively close to the ground and spread in a hexagonal design of 7, 13, or 19 points, with one in the center, over a selected location. Depending on the type of records sought, he continued, comparatively light charges are placed from 5 to 85 feet apart and detonated simultaneously. Tests have shown the above-ground explosion method, on which patents have been applied for, does not incur the risks of the shot hole method as regards damaging nearby structures of concrete or other solid material. It also eliminates the danger of falling stones. The Poulter method, however, produces a louder explosion than the shot hole method, although its concussion effect is almost negligible.

### Library of Congress Has "History of Radar"

A "History of Radar," prepared by the Office of Scientific Research and Development as a full-length portrait of the war's second greatest secret weapon, is now available to the American public. Prepared under the direction of Professor Henry E. Guerlac, now with Cornell University, it is a 1,300-page manuscript in four parts. Perhaps the most exhaustive study of the development of radar yet produced, the history covers all phases of wartime research, production of radar by American industry, and the military use of radar on the ground, in naval and antisubmarine warfare, and in the air for bombing and navigational uses.

The development of radar is traced from the pioneering of Maxwell and Hertz in the last century to the discovery of pulse-ranging techniques by Breit and Tuve 20 years ago. The Breit-Tuve method, used for measuring the height of the ionosphere, was the basis for "long wave" radar perfected at about the same time in France, Germany, Britain, and the United States just prior to the war. Microwave radar, however, was a wartime development of England and the United States, which not only was more efficient than previous techniques, but was completely unknown to the enemy. By helping to rout the Nazi submarine fleet it contributed greatly to Germany's eventual defeat.

While British and Canadian developments are treated carefully, chief emphasis in the history is placed on the microwave radar program in the United States. Interest centers on how, in an amazingly short time, government, science and industry co-operated to bridge the gap between basic physical discovery and the production of operating equipment. Mr. Green described this story of successful co-operation, led by the radiation laboratory of the Massachusetts Institute of Technology, as a guide-post for future research relationships among industry, government and the universities.

The "History of Radar," originally prepared as a nonpublic document, includes an unprecedented amount of information hitherto classified as secret. Consequently the study, now freed from security restrictions because of the industrial values of radar, is a work of unmatched thoroughness. Details include an account of the actual observation of radar in combat by scientists detailed from the development laboratories. The manuscript is available from the Library of Congress, Government Publication Room, Washington, D. C., in both photostatic and microfilm form. Prices for both are available from the afore-mentioned address.

### 10,000-Watt Lamp to Aid Moviemakers

The brightest cadmium mercury vapor lamp ever made in America—a 10,000-watt sphere of quartz—was shown for the first time at the 64th semiannual conference of the Society of Motion Picture Engineers, meeting in the Statler Hotel, Washington, D. C. The experimental lamp, developed by Westinghouse lamp division engineers, produces high-powered light that streams from a high pressure arc about half the brightness of the sun and three-eighths of an inch in length.

The high brilliance of the short-arc lamp and its cool light of near-daylight color should qualify it for both spotlight and floodlight service in motion picture studios. The addition of a small amount of cadmium to the mercury inside the rugged quartz bulb adds enough red and other colors to the light to make it suitable for color movies. It is expected that this lamp, which can be burned in a simple portable projector, eventually will supplement the carbon arc lamp now common to motion picture studios. Preliminary laboratory tests indicate that it will rival the carbon arc in brilliance.

In short-arc lamps, peak brilliance is attained by the high mercury vapor pressures built up within the quartz bulb and squeezed inside the arc. The short-arc makes possible optical control heretofore unknown. The short-arc lamp, described as an "instant starting source of high brightness electronic light," operates on an auxiliary circuit that makes possible instant restarting at peak brilliance. When restarting other mercury vapor lamps, a cool-down period is customary before the lamp can be restarted and then there is a further delay to bring it to top brilliance.

### Joint Office Set Up for Air Documents

Joint operation by the United States' Navy and Air Force of a central documentary service for the collection, publication, and dissemination of air-technical information has been announced by Secretary of Defense James Forrestal. The new Central Air Documents Office at Wright-Patterson Air Force Base, Dayton, Ohio, formalizes a working arrangement between the Air Force Air Materiel Command and the Navy's Bureau of Aeronautics. Its major policies are determined by the Research and Development Board of the National Military Establishment.

The existing Air Documents Division, Intelligence Department, Air Materiel Command, Air Force, which already is staffed jointly by the Air Materiel Command and the Bureau of Aeronautics, Navy, was designated officially as the Central Air Docu-

## Power Station Cooled by Water

**These three pumps are driven by 300-horsepower motors and are part of the company-owned and operated power-generation facilities at the Houston, Tex., works of the Diamond Alkali Company. They can supply a total of 60,000,000 gallons of water a day for plant requirements in the production of chlorine and caustic soda and for cooling**

ments Office. It remains under administration of the Air Materiel Command. A working committee, composed of an equal number of Air Force and Navy personnel, will be appointed with rotating chairmanship by designated representatives of the two departments to determine minor policies and operation. The chairman of the working committee reports to the Research and Development Board problems that are beyond his committee's scope.

## Mobile Betatron X Rays Penetrate 16-Inch Steel

The world's first mobile betatron, a 10-million-volt X-ray generator whose rays are capable of penetrating 16 inches of steel, now is being installed at the Naval Ordnance Laboratory, White Oak, Md. The new equipment is so powerful it must be housed in a special building surrounded by 3-foot walls of reinforced concrete in order to protect personnel. Built for the Navy Bureau of Ordnance by the General Electric Company's general engineering and consulting laboratory at Schenectady, N. Y., the machine will be placed in operation some time after the first of the year.

The massive betatron, first industrial machine whose rays will penetrate steel thicker than 12 inches, is unique in that it may be aimed in any direction whereas all other betatrons, cyclotrons, and similar nuclear research equipment of this type are held in a fixed position. It will be used at White Oak principally for studying the complex internal assemblies of mines, torpedoes, and other items of Naval ordnance.

By means of the X-ray "shadowgraphs" that it will take, Naval Ordnance Laboratory scientists may determine in early developmental stages the effects of stresses, strains, and shocks upon delicate internal components. Proper engineering clearances also may be observed. Techniques developed through use of the machine at White Oak are expected to be useful subsequently in many fields. The machine also will afford the Naval Ordnance Laboratory sharp, clear internal pictures of thick sections of steel such as castings, welds, and armor plates. These pictures will reveal defects such as cracks, blowholes, and other flaws which cannot be detected by any other means.

## Army Officer Reserves Seek Technical Men

In an effort to establish a Reserve Officers' training program that will pose an intellectual challenge to men of scientific training, the United States Army is establishing Organized Reserve Research and Development Groups. This program aims to avoid the lack of properly trained scientists and technologists in times of emergency by establishing peacetime reserve training in keeping with the professional interests of these men in civilian life.

Aims of the program include: maintenance of the useful affiliation of engineers and other technicians and scientists with the organized Reserve Corps; provision of peacetime Reserve assignments for these officers, enabling optimum utilization of their education, experience, and skills; provision of mobilization assignments which will fully utilize their talents; adequately prepare these officers for mobilization.

Research officers who currently are engaged in civilian research, college or university teaching, or industrial research and development, are eligible to make application for assignment to an Organized Reserve Research and Development Group. A group may be organized in any locality where there are 20 or more qualified officer scientists who desire to participate in the program. To date 18 groups have been organized, with 12 more in the process of being formed. The entire program is outlined in Department of the Army Circular 127, dated May 5, 1948.

Those electrical engineers and other scientists who are not Reserve officers and wish to become one, may gain Reserve commissions ranging from second lieutenant to full colonel, depending upon age, education, experience, and physical condition. Full details of the program for commissioning of civilian electrical engineers and other scientists are provided in Department of the Army Circular 210, dated July 14, 1948. An outline of the program can be found on page 1025, the October 1948 issue of *ELECTRICAL ENGINEERING*.

**World Engineering Conference.** The Second International Technical Congress will be held at Cairo, Egypt, March 20–26, 1949. The program will be divided into three sections: section A will deal with all problems connected with raw materials, such as geographic distribution, exploitation, utilization, and problems of energy; section B will discuss the social aspect of technical development and of raw material problems; section C will take up the problem of water in the Middle-East, covering waterways, seas, rain water, and subterranean water. The congress has the endorsement of the committee on international relations of the Engineers Joint Council.

**Kansas City to Have Exposition.** The Electric Association of Kansas City will sponsor an electrical exposition, March 2–6, 1949, which will embrace the most recent developments in electricity and electronics for civilian and military use. To be called "The Exposition of Electrical Progress," it is expected that the affair will attract the exhibits of firms associated with the manufacture of electric appliances and equipment. Already lined up are exhibits by the makers of electronic devices, radio, television, lighting equipment, and electric industrial equipment. Also, several of the nation's leading radio network shows will broadcast from the exposition.

**Cottrell, Scientist and Inventor, Dies.** Doctor Frederick Gardner Cottrell, famous inventor of the Cottrell Electrical Precipitator and a leading scientist, died November 16, 1948. Born in Oakland, Calif., in 1877, he was graduated from the University of California in 1896. After doing graduate work abroad, he returned to the United States to be, in turn, an instructor and professor at the University of California, director of the United States Bureau of Mines, and director of the Fixed Nitrogen Research Laboratory of the United States Department of Agriculture. In 1912, Doctor Cottrell organized Research Corporation of New York and turned over to it almost all the proceeds and subsequent royalties of his Precipitator. Through this corporation, grants totalling several million dollars have been made to support various research projects.

**Radio Standards to Be Co-ordinated.** The American Standards Association sectional committee on radio is being reactivated under the sponsorship of the Institute of Radio Engineers. Its immediate problem will be the reviewing of Joint Army–Navy specifications and the co-ordination of civilian standards with them. Standards formulating committees of professional and trade associations will aid the committee, and its findings will serve as a basis for proposed changes in existing industry standards and JAN specifications. The objective of this committee will be to promote interchangeability of civilian and JAN components wherever possible to facilitate and expedite procurement of a wide range of radio and electronic components in the event of national emergency.

**Worthley Named Committee Head.** Doctor Harlan N. Worthley, director of the agricultural and textile chemicals research department of Merck and Company, Inc., Rahway, N. J., has been appointed executive director of the committee on chemical warfare of the Research and Development Board, National Military Establishment. A former professor of economic entomology at Pennsylvania State College, Doctor Worthley served as a major, lieutenant colonel, and colonel in the United States Army Chemical Corps in World War II. He is a member of the Officers' Reserve Corps.

**$20,000,000 Program Set for MIT.** The committee on financing development of the Massachusetts Institute of Technology, Cambridge, Mass., has approved a $20,000,000 program to "keep the Massachusetts Institute of Technology in the forefront of scientific education." About half of the amount is to be assigned to endowments and unrestricted funds, with the balance to be invested in new buildings and investments to enhance the institute's technological facilities. Among the committee's recommendations were included nuclear science and engineering laboratory buildings, and buildings for research and study in metals processing, biology and food technology, hydrodynamics, and electronics. Also included are a new gymnasium and auditorium, and a new faculty club. This development program is based on a normal postwar enrollment of some 4,500 students, nearly 1,500 more than the normal prewar enrollment.

## Westinghouse Teaches Utility Engineers

**Young electrical utility engineers as seen working a problem on the d-c calculating board at the Westinghouse Electric Corporation's East Pittsburgh, Pa., plant. This select group is taking part in the 1948–49 session of the 7-month graduate-level course in electric transmission, distribution, and generation procedures which Westinghouse is sponsoring in co-operation with a limited number of utility companies throughout the United States**

**NBS Names Combustion Section Head.** The National Bureau of Standards has announced that Doctor Ernest F. Fiock, a leading authority in the field of combustion, will be the chief of the newly organized Combustion Section. The increasing importance of combustion research, particularly in its applications to gas turbines and jet engines, has made the formation of this section necessary. Doctor Fiock will direct investigations in the determinations of burning velocities, flame temperatures, burner performance, and methods and instrumentation applicable to the handling and metering of fuels to the measurement of temperatures of streaming gases. Doctor Fiock, who has been with the National Bureau of Standards since 1926, also serves as consultant to the Armed Forces on combustion problems. During World War II, he conducted fundamental research in jet propulsion, and since then has been conducting research in basic problems and practical applications in that field.

**F. L. Wilkinson, Jr., Named School President.** Ford L. Wilkinson, Jr., dean of the United States Naval Postgraduate School, Annapolis, Md., has been appointed to the presidency of Rose Polytechnic Institute, Terre Haute, Ind. A graduate of the United States Naval Academy, he was in the naval service from 1917 to 1927. He held various engineering positions following that period, the majority of which were on the faculties of schools and colleges of engineering. A former vice-president of The American Society of Mechanical Engineers, Wilkinson also holds membership in the American Society for Engineering Education, the Academy of Political Science, and Tau Beta Pi, Phi Kappa Phi, and Sigma Tau fraternities.

**GE Analyzer for Indian Institute.** An a-c network analyzer, for installation at the Indian Institute of Science, Bangalore, India, is under construction at the General Electric Company's Philadelphia, Pa., works. When completed during 1949 the instrument will be installed in a newly-built, high-voltage laboratory which is expected to be one of the most modern in Asia. It will be used to reproduce, in miniature, the electric circuits of vast power system networks and in solving the mathematical problems associated with them. Contract negotiations were handled through the International General Electric Company.

**New Weights and Measures Staff Addition.** William S. Bussey, formerly chief of the division of weights and measures for the state of Texas, has been appointed assistant chief of the Office of Weights and Measures, National Bureau of Standards. He will participate in planning and conducting the bureau's co-operative weights and measures program with state and local administrative authorities. As assistant chief, Bussey will be responsible in a large part for the bureau's field work, and will help direct the Annual National Conference on Weights and Measures.

**New Scientific Journal for South.** A new scientific journal, to be called the *Journal of Southeastern Research* will be published by the Southeastern Research Institute of Atlanta, Ga., and will cover engineering engineering research progress in 11 southeastern states. The new quarterly, to begin publication in January 1949, will carry technical papers, news reports, and editorial studies reflecting the rapid growth of research activity in the states between Virginia and Texas. It will obtain material from more than 20 important research centers in universities, some 10 state engineering experiment stations, and nearly 200 industrial laboratories, plus governmental laboratories and atomic development installations. Aimed at providing a "conference table" for research leaders in that area, the journal also will afford engineers of other sections an opportunity to contribute to the development of the engineering profession in the southeast. Editorial offices will be at 5009 Peachtree Road, Atlanta, Ga.

**NBS Names Marton Electron Physics Head.** Doctor Ladislaus L. Marton has been appointed chief of the electron physics section of the National Bureau of Standards, and will direct research on the basic theory methods, and applications of electron- and ion-beam devices, including interaction phenomena between particles and matter. Doctor Marton has been with the Bureau of Standards since 1946. Previously he was on the faculty of Stanford University, serving as head of the division of electron optics and as associate professor of physics. During the World War II, he trained Army and Navy personnel in the techniques of X-ray inspection and was also technical adviser to various wartime industries. Doctor Marton has received international recognition for his work in the development and perfection of the electron microscope and is at present working on the manuscript of his forthcoming book on electron optics. He also has contributed numerous articles to scientific journals.

**Zahl Named to New Position.** The United States Army Signal Corps has announced that Doctor Harold A Zahl, physicist, has been named to fill the newly created post of director of research for the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. These laboratories are responsible for the research and development of ground signal equipment and special electronic devices for the United States Army and the Armed Forces at large. Doctor Zahl's responsibilities will cover research conducted within the laboratories and an extended external program carried on by contract in universities and industry.

## OTHER SOCIETIES

### AIME Elects Young as 1949 President

The election of Lewis Emanuel Young, of Pittsburgh, Pa., as president of the American Institute of Mining and Metallurgical Engineers for 1949 was announced at the meeting of the board of directors in New York, N. Y., on November 17. Doctor Young is a consulting mining engineer and from 1927 to 1939 was vice-president of the Pittsburgh Coal Company, which has been consolidated with a number of smaller companies to become the Pittsburgh Consolidation Coal Company, of Pittsburgh. Doctor Young has been active in the AIME for a number of years, having been elected a director in 1937 and serving as vice-president from 1942 to 1945. He has written numerous technical papers on mine mechanization and mining practice for technical societies and engineering periodicals.

Announcement also was made of the election of two vice-presidents: Augustus Braun Kinzel, president, Union Carbide and Carbon Research Laboratories, New York, N. Y.; and Philip Kraft, vice-president, Newmont Mining Corporation, New York, N. Y. Four new directors elected were: William J. Coulter, general manager, Climax Molybdenum Company, Denver, Colo.; James L. Head, mining engineer, Anaconda Copper Mining Company, New York, N. Y.; W. M. Peirce, chief, research division, New Jersey Zinc Company, Palmerton, Pa.; and George P. Swift, consulting engineer, Waltham, Mass.

Elected also were six new directors ex officiis as chairmen of professional divisions of the Institute: Frederick N. Rhines (chairman, Institute of Metals division) associate professor of metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.; Lloyd E. Elkins (chairman, petroleum division), assistant chief production engineer, Stanolind Oil and Gas Company, Tulsa, Okla.; C. D. King (chairman, iron and steel division), United States Steel Corporation, Pittsburgh, Pa.; E. R. Price (chairman, coal division), general superintendent of mines, Inland Steel Company, Wheelwright, Ky.; Howard A. Meyerhoff (chairman, industrial minerals division), professor of geology, Smith College, Northampton, Mass.; S. Joseph Swainson (chairman, mineral beneficiation division), director, ore dressing department, American Cyanamid Company, Stamford, Conn.

**Astronomers Meet at Yale.** The 80th meeting of the American Astronomical Society was held at Yale University, New Haven, Conn., from December 28–31, 1948. About 200 astronomers from the United States and Canada attended. A special symposium on microwave astronomy was held under the supervision of Professor Charles R. Burrows, head of the school of electrical engineering, Cornell University, and was followed by a teacher's conference on current problems facing instructors of astronomy. Major talks were given by Dirk Brouwer, director of the Yale Observatory; Gerald M. Clemence, director of the Nautical Almanac office of the United States Naval Observatory; and Otto Struve, chairman of the department of astronomy at the University of Chicago, and president of the American Astronomical Society. Harlow Shapley, director of the Harvard University Observatory, led discussion of the meeting last summer held by the International Astronomical Union at Zurich, Switzerland.

### New Officers Selected by IRE for Coming Year

The Institute of Radio Engineers has announced the election of Stuart L. Bailey as president of the institute for the year 1949. Arthur S. McDonald of Australia was elected vice-president. Mr. Bailey has been a Fellow of the IRE since 1943. He is a consulting radio engineer and partner of the firm Jansky and Bailey, Washington, D. C. Mr. McDonald, a Fellow of the IRE since 1941, is chief engineer of the Overseas Telecommunication Commission, Sydney, Australia.

For director-at-large, for the 1949–1951 term, the following members were elected: Doctor William L. Everitt, Fellow of the IRE since 1938, professor and head of the department of electrical engineering, University of Illinois, Urbana, Ill.; Donald G. Fink, Fellow of the IRE since 1947, editor-in-chief, *Electronics*, McGraw-Hill Publishing Company, New York, N. Y.

### Future Meetings of Other Societies

**American Institute of Consulting Engineers.** Annual meeting. January 5, 1949, 75 West Street, New York, N. Y.

**American Chemical Society.** Semiannual meeting. March 28–April 1, 1949, San Francisco, Calif.

**American Society of Chemical Engineers.** Los Angeles, Calif., regional meeting, March 6–9, 1949; Tulsa, Okla., regional meeting, April 8–12, 1949.

**American Institute of Mining and Metallurgical Engineers.** Annual meeting. February 14–17, 1949, Fairmont Hotel, San Francisco, Calif.

**American Management Association.** Production meeting. April 14–15, 1949, Hotel Statler, New York, N. Y.

**American Society of Heating and Ventilating Engineers.** Annual meeting. January 24–27, 1949, Chicago, Ill.

**American Society of Photogrammetry.** Annual meeting. January 12–14, 1949, Hotel Shoreham, Washington, D. C.

**Chicago Production Show.** Chicago Technical Societies Council. March 14–17, 1949, Hotel Stevens, Chicago, Ill.

**Materials Handling Show.** Third annual meeting. January 10–14, 1949, Convention Hall, Philadelphia, Pa.

**National Electrical Manufacturers Association.** Winter Convention. March 13–18, 1949, Edgewater Beach Hotel, Chicago, Ill.

**National Electrical Wholesalers Association.** May 2–6, 1949, Netherland Plaza Hotel, Cincinnati, Ohio.

**National Fire Protection Association.** May 16–19, 1949, Fairmont Hotel, San Francisco, Calif.

**Society of Automotive Engineers.** January 10–14, 1949, Book-Cadillac Hotel, Detroit, Mich.

**Third International Lighting Exposition and Conference.** Week of March 28, 1949, Hotel Stevens, Chicago, Ill.

John V. L. Hogan was elected regional director for 1949 and 1950 of region 2, the North Central Atlantic Region. He is president of the Interstate Broadcasting Company, Inc., radio stations *WQXR*, *WQXQ*; president of Radio Inventions, Inc.; and president of Faximile, Inc., New York, N. Y. Mr. Hogan became a Fellow of the IRE in 1915, and was president in 1920; vice-president from 1916 to 1919; and manager from 1913 to 1915 and again from 1921 to 1923. From 1916 to 1920, and from 1932 to 1936, and in 1948, he was a director. George R. Town was elected regional director for 1949 and 1950 of region 4, the East Central Region. He is manager of engineering and research, Stromberg-Carlson Company, Rochester, N. Y. Ben Akerman was elected regional director for 1949 and 1950 of region 6, the Southern Region. He is chief engineer of radio station *WGST*, Atlanta, Ga. Frank H. R. Pounsett, Fellow of the IRE since 1947, was elected regional director for 1949 and 1950 of region 8, the Canadian Region. He is chief engineer of the Stromberg-Carlson Company, Ltd., Toronto, Ontario, Canada

**Spring Meeting for RMA-IRE.** The fourth annual spring meeting, sponsored jointly by the Radio Manufacturers Association and the Institute of Radio Engineers in the interest of radio transmitter and radio transmitting tube engineers, will be held at the Benjamin Franklin Hotel, Philadelphia, Pa. April 25–27, 1949. The program, of interest to television, frequency modulation, navigational aids, aircraft, and broadcast radio engineers, will include technical papers by outstanding authorities and visits to local radio and television studios and plants engaged in the manufacture of radio and television equipment.

**NEMA Elects 1949 Officers.** B. W. Clark, vice-president in charge of sales, Westinghouse Electric Corporation, Pittsburgh, Pa., was elected president of the National Electrical Manufacturers Association at that group's 22d annual meeting in November. Three new members were elected to the board of governors. They were David J. Biller, president of Day-Brite Lighting, Inc., St. Louis Mo; Raymond C. Cosgrove, executive vice-president, Avco Manufacturing Corporation, Cincinnati, Ohio; Roy E. Murphy, vice-president in charge of sales, I-T-E Circuit Breaker Company, Philadelphia, Pa. Also elected were four new vice-presidents and a new treasurer. Nine members of the board of governors were re-elected.

**Louisiana Engineers to Meet.** The Louisiana Engineering Society has announced that it will hold its 1949 annual meeting at the St. Charles Hotel in New Orleans, January 13–15, 1949. Technical sessions will be sponsored by local chapters of various engineering societies and institutes of electrical, chemical, illuminating, heating and ventilation, refrigerating, military, civil, mining and metallurgical, mechanical, geologic and plastics engineers. A registration

of 800 is expected including engineering students from leading southern schools and colleges. In addition to the reading of technical papers and ensuing discussions, the meeting will feature technical exhibits, industrial field trips, a trip around the harbor, a banquet, and a ball.

## HONORS • • • • • •

### Medals Conferred on Kodak Scientists

Two internationally known photographic scientists from the Eastman Kodak Company, Rochester, N. Y., have had medals from photographic societies in two countries conferred upon them.

Doctor C. E. Kenneth Mees, vice-president in charge of research, was the recipient of the Photographic Society of America's first presentation of its Progress Medal. The award was made in November at the Society's 1948 convention in Cincinnati, Ohio, and was voted to Doctor Mees for his many technical, literary, and inspirational contributions to photography.

The first Rodman Medal award of the Royal Photographic Society, London, England, ever to be presented to a citizen of the United States was given to Harold F. Sherwood of Kodak's research laboratories. This medal was established in 1935, and is awarded for outstanding work in photomicrography, radiography, and other scientific fields.

Sherwood's exhibit, "Microradiographs of Thin Sections of Metal, Wood, and Paper," was selected by the society's scientific and technical section as the outstanding one at its 93d Annual International Exhibition in London. Sherwood, with Kodak since 1929, has done intensive research in radiography for 15 years, and has published 14 papers on the subject.

### James H. McGraw Awards Made for 1948

Two of the awards established 23 years ago by James H. McGraw, founder of the McGraw-Hill Publishing Company, to encourage constructive thinking for the advancement of the electrical industry have been awarded for the year 1948. Both awards consist of a bronze medal and a purse of one hundred dollars.

The first, the James H. McGraw Award Contractors Medal, given for personal contributions to the contracting branch of the electrical industry, has been received by Laurence W. Davis, treasurer of the National Electrical Contractors Association. Presentation was made during the annual meeting of that association in December of 1948.

The second, the James H. McGraw Award Manufacturers Medal, given for personal contributions to the manufacturing branch of the electrical industry, was given to R. Stafford Edwards, president of Edwards and Company, Inc. Edwards received the award at the annual meeting of the National Electrical Manufacturers Association in November 1948.

**Gas Turbine Pioneer Honored.** Charles G. Curtis of New York, internationally known engineer and pioneer in the field of gas turbines, was presented with the first annual award of the gas turbine power division of The American Society of Mechanical Engineers' annual meeting in November. The citation was for his early work which resulted in the first American patent covering a complete gas turbine power plant. Born in 1860, Curtis is still active as president of the International Curtis Marine Turbine Company of New York, N. Y., which carries on the work he started in 1896 with the invention of the Curtis steam turbine.

**Beatty Receives Egleston Medal.** A. Chester Beatty, English mining administrator and 1898 graduate of the Columbia University school of engineering, has received the Egleston Medal for distinguished engineering achievement awarded by the Columbia Engineering School Alumni Association. The citation for the award states that Beatty is "internationally known for his outstanding achievements in the low grade copper mines of this country, the.... mining of African diamond deposits, the... development of Northern Rhodesia copper fields, as well as the development of lead-zinc mines in Yugoslavia." Presentation was made at dinner in the recipient's honor at the Columbia University Club, New York, N. Y.

**GE's President Given Medal.** Charles E. Wilson, president of the General Electric Company, has been awarded the Crozier Gold Medal of the American Ordnance Association for distinguished service rendered by him as vice-chairman of the War Production Board in World War II, and for his leadership in the fields of science and industry. The award was made at the Industrial Preparedness meeting held in New York, N. Y., December 6, 1948.

## JOINT ACTIVITIES

### Engineering Societies Start Library Facilities Survey

A survey of the Engineering Societies Library is being made to determine how it can serve the engineering profession better. Although the Engineering Societies Library currently serves 40,000 engineers annually, it is expected that the survey will show how the library can be of greater value to the profession generally and especially to the members of the four societies that founded and that support the library. Thirty-five years ago the American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the AIEE joined their libraries to form the Engineering Societies Library which is

*(Continued on page 88)*

## Eta Kappa Nu Jury of Award

**Seated from left to right are the following members of the Eta Kappa Nu Jury of Award which selected the 1948 recipient of that society's recognition award to an outstanding young electrical engineer: J. E. Murdoch (A '27), chief engineer, Bell Telephone Company of Pennsylvania, Philadelphia, Pa.; R. W. Wilbraham (F '45), chief electrical engineer, electrical department, United Engineers and Constructors, Inc., Philadelphia, Pa.; N. S. Hibshman (F '41), dean of the school of science and technology, Pratt Institute, Brooklyn, N. Y.; O. W. Eshbach (F '37), dean of the Northwestern Technological Institute, Evanston, Ill.; S. R. Warren, Jr. (M '41), associate professor of electrical engineering, Moore school of electrical engineering, and associate professor of radiological physics, graduate school of medicine, University of Pennsylvania, Philadelphia, Pa.; E. L. Moreland (F '21), chairman of the jury, Jackson and Moreland, Engineers, Boston, Mass.; C. F. Craig (M '27), vice-president, American Telephone and Telegraph Company, New York, N. Y. For details and background concerning the award, plus a list of past winners, see page 1224, ELECTRICAL ENGINEERING, December 1948. The award will be made during the AIEE winter general meeting on the night of January 31, 1949, in the Tudor Room of the Henry Hudson Hotel, New York, N. Y.**

# List of Undergraduate Engineering Curricula Accredited by ECPD as of October 29, 1948

(Subject to periodic revision)

**Akron, University of:** Electrical[c], mechanical (industrial and aeronautical options)[c]

**Alabama Polytechnic Institute:** Civil, electrical, mechanical

**Alabama, University of:** Aeronautical, civil, electrical, industrial, mechanical, mining

**Alaska, University of:** Civil, mining (including metallurgical and geological options)

**Arizona, University of:** Civil, electrical, mechanical, mining

**Arkansas, University of:** Civil, electrical, mechanical

**Brooklyn, Polytechnic Institute of:** Chemical (day and 8-year evening), civil[a], electrical[a], mechanical[a]

**Brown University:** Civil, electrical, mechanical

**Bucknell University:** Chemical, civil, electrical, mechanical

**California Institute of Technology:** Aeronautical (5- and 6-year courses), chemical (5-year course), civil, electrical, mechanical

**California, University of:** Civil, electrical, mechanical, metallurgical (metallurgy), mining, petroleum

**Carnegie Institute of Technology:** Chemical[a], civil[a], electrical[a], mechanical[a], metallurgical[a]

**Case Institute of Technology:** Chemical, civil, electrical, mechanical, metallurgical

**Catholic University of America:** Aeronautical, architectural, civil, electrical, mechanical

**Cincinnati, University of:** Aeronautical[c], chemical[c], civil[c], electrical[c], mechanical[c], metallurgical[c]

**Citadel, The:** Civil

**Clarkson College of Technology:** Chemical, civil, electrical, mechanical

**Clemson Agricultural College:** Civil, electrical, mechanical

**Colorado School of Mines:** Geological, metallurgical, mining, petroleum production

**Colorado State College:** Civil, electrical, mechanical

**Colorado, University of:** Aeronautical, architectural, civil, electrical, mechanical

**Columbia University:** Chemical[b], civil[b], electrical[b], industrial[b], mechanical[b], metallurgical[b], mining[b]

**Connecticut, University of:** Civil, electrical, mechanical

**Cooper Union School of Engineering:** Chemical[d], civil[d], electrical[d], mechanical[d]

**Cornell University:** Chemical, civil, electrical, industrial (administrative), mechanical

**Dartmouth College:** Civil

**Delaware, University of:** Chemical, civil, electrical, mechanical

**Denver, University of:** Electrical, mechanical

**Detroit, University of:** Aeronautical[c], architectural[c], chemical[c], civil[c], electrical[c], mechanical[c]

**Drexel Institute of Techology:** Civil[c-r], electrical[c-r], mechanical[c-r]

**Duke University:** Civil, electrical, mechanical

**Fenn College:** Electrical[a,c-r], mechanical[a,c-r], metallurgical[a,c-r], structural[a,c-r]

**Florida, University of:** Aeronautical, chemical, civil (includes public health option), electrical, industrial, mechanical

**George Washington University:** Civil, electrical, mechanical

**Georgia Institute of Technology:** Aeronautical, ceramic, chemical[c-r], civil[c-r], electrical[c-r], mechanical[c-r]

**Harvard University**[d]**:** Civil, electrical (includes communication engineering) industrial (engineering and business administration), mechanical, metallurgical (physical metallurgy), sanitary

**Howard University:** Civil, electrical, mechanical

**Idaho, University of:** Civil, electrical, mechanical, metallurgical (metallurgy), mining (includes geographical option)

**Illinois Institute of Technology:** Chemical, civil, electrical, mechanical

**Illinois, University of:** Architectural, ceramic (technical option), chemical, civil, railway civil, electrical, railway electrical, general[f], mechanical, railway mechanical, metallurgical, mining

**Iowa State College:** Agricultural, architectural, ceramic, chemical, civil, electrical, general[f], mechanical

**Iowa, State University of:** Chemical, civil, electrical, mechanical

**Johns Hopkins University:** Civil, electrical, mechanical

**Kansas State College:** Agricultural, architectural, civil, electrical, mechanical

**Kansas, University of:** Architectural, civil, electrical, mechanical, mining

**Kentucky, University of:** Civil, electrical, mechanical, metallurgical, mining

**Lafayette College:** Civil, electrical, industrial (administrative), mechanical, metallurgical, mining

**Lehigh University:** Chemical, civil, electrical, industrial, mechanical, metallurgical, mining

**Louisiana Polytechnic Institute:** Civil, electrical, mechanical

**Louisiana State University:** Chemical, civil, electrical, mechanical, petroleum

**Louisville, University of:** Chemical[c], civil[c], electrical[c], mechanical[c]

**Maine, University of:** Civil, electrical, general[f], mechanical

**Manhattan College:** Civil, electrical

**Marquette University:** Civil[c], electrical[c], mechanical[c]

**Maryland, University of:** Chemical, civil, electrical, mechanical

**Massachusetts Institute of Technology:** Aeronautical, chemical, civil (includes building and construction engineering and sanitary option), electrical[c-r], general[f], industrial (business and engineering administration), mechanical[c-r], metallurgical (metallurgy), naval architecture and marine engineering (including marine transportation)

**Michigan College of Mining and Technology:** Chemical, civil, electrical, mechanical, metallurgical, mining

**Michigan State College:** Civil, electrical, mechanical

**Michigan, University of:** Aeronautical, chemical, civil, electrical, engineering mechanics, mechanical, metallurgical, naval architecture and marine engineering

**Minnesota, University of:** Aeronautical, chemical, civil, electrical, mechanical metallurgical, mining, petroleum

**Mississippi State College:** Civil, electrical, mechanical

**Missouri School of Mines and Metallury.** Ceramic, civil, electrical, metallurgical, mining (mine) (including petroleum option)

**Missouri, University of:** Chemical, civil, electrical, mechanical

**Montana School of Mines:** Geological, metallurgical, mining

**Montana State College:** Chemical, civil, electrical, mechanical

**Nebraska, University of:** Agricultural, architectural, civil, electrical, mechanical

**Nevada, University of:** Electrical, mechanical, mining

**New Hampshire, University of:** Civil, electrical, mechanical

**New Mexico College of Agricultural and Mechanic Arts:** Civil, electrical, mechanical

**New Mexico School of Mines:** Geological, mining, petroleum

**New Mexico, University of:** Civil, electrical, mechanical

**New York, College of the City of:** Civil[a], electrical[a], mechanical[a]

**New York State College of Ceramics** (at Alfred University): Ceramic

**New York University:** Aeronautical, chemical (day and 7-year evening), civil[a], electrical[a], industrial (administrative), mechanical[a]

**Newark College of Engineering:** Civil[c-r], electrical[c-r], mechanical[c-r]

**North Carolina State College:** Ceramic, chemical, civil, electrical, industrial, mechanical (includes aeronautical option)

**North Dakota Agricultural College:** Architectural, civil, electrical, mechanical

**North Dakota, University of:** Civil, electrical, mechanical, mining

**Northeastern University:** Chemical[c], civil[c], electrical[c], industrial[c], mechanical[c]

**Northwestern University:** Chemical, civil, electrical, mechanical

**Norwich University:** Civil, electrical

**Notre Dame, University of:** Aeronautical, civil, electrical, mechanical, metallurgical (metallurgy)

**Ohio State University:** Ceramic, chemical, civil, electrical, industrial, mechanical, metallurgical, mining (mine)

**Oklahoma Agricultural and Mechanical College:** Civil, electrical, industrial, mechanical

**Oklahoma, University of:** Architectural, chemical, civil, electrical, mechanical, petroleum

**Oregon State College:** Chemical, civil, electrical, mechanical

**Pennsylvania State College:** Architectural, ceramic (ceramics), chemical, civil, electrical, fuel technology, industrial, mechanical, metallurgical (metallurgy), mining, petroleum and natural gas, sanitary

**Pennsylvania, University of:** Chemical, civil, electrical, mechanical

**Pittsburgh, University of:** Chemical, civil, electrical, industrial, mechanical, metallurgical, mining, petroleum

**Pratt Institute:** Electrical, mechanical

**Princeton University:** Chemical, civil, electrical, mechanical

**Purdue University:** Aeronautical, chemical, civil, electrical, mechanical, metallurgical

**Rensselaer Polytechnic Institute:** Aeronautical, chemical, civil, electrical, industrial, mechanical, metallurgical

**Rhode Island State College:** Civil, electrical, mechanical

**Rice Institute:** Chemical, civil, electrical, mechanical

**Rochester, University of:** Chemical, mechanical

**Rose Polytechnic Institute:** Civil, electrical, mechanical

**Rutgers University:** Civil, electrical, mechanical, sanitary

**Santa Clara, University of:** Civil, electrical, mechanical

**South Carolina, University of:** Civil, electrical, mechanical

**South Dakota State College:** Civil, electrical, mechanical

**South Dakota School of Mines:** Civil, electrical, general[f], metallurgical, mining

**Southern California, University of:** Civil, electrical, mechanical, petroleum

## Explanatory Notes

* Due to the effects of the war upon education in chemical engineering, all accrediting of chemical engineering curricula ceased with the 1943 list until resumption of the inspection program in 1947–48. The accredited list shown here includes chemical engineering curricula: those on the 1943 list and also those reinspected during 1947–48 and approved by the American Institute of Chemical Engineers.

(*a*). Accrediting applies to the day and evening curricula.

(*b*). Accrediting applies to the 4-year and 5-year curricula leading to the bachelor of science degree.

(*c*). Accrediting applies to the co-operative curriculum only.

(*c-r*). Accrediting applies to both the co-operative and regular curricula.

(*d*). Accrediting applies to day and to 6-year evening curricula in the Cooper Union School of Engineering as submitted to ECPD.

(*e*). Accrediting applies only to curriculum as submitted to ECPD and upon completion of which a certificate is issued by Harvard University certifying that the student has pursued such a curriculum.

(*f*). The accrediting of a curriculum in general engineering implies satisfactory training in engineering sciences and in the basic subjects pertaining to several fields of engineering; it does not imply the accrediting, as separate curricula, of those component portions of the curriculum such as civil, mechanical, or electrical engineering that usually are offered as complete professional curricula leading to degrees in these particular fields.

## List of Undergraduate Engineering Curricula Accredited by ECPD as of October 29, 1948 (continued)

**Southern Methodist University:** Civil[e], electrical[e], mechanical[e]

**Stanford University:** Civil, electrical, mechanical, metallurgical, mining, petroleum

**Stevens Institute of Technology:** General[f]

**Swarthmore College:** Civil, electrical, mechanical

**Syracuse University:** Chemical, civil, electrical, industrial (administrative), mechanical

**Tennessee, University of:** Chemical[c−r], civil[c−r], electrical[c−r], mechanical[c−r]

**Texas, Agricultural and Mechanical College of:** Aeronautical, chemical, civil (including municipal and sanitary option), electrical, mechanical, petroleum (4- and 5-year courses)

**Texas College of Mines and Metallurgy:** Mining (mining option, mining geology, metallurgy option)

**Texas Technological College:** Civil, electrical, mechanical

**Texas, University of:** Aeronautical, architectural, chemical, ceramic, civil, electrical, mechanical, petroleum (petroleum production)

**Toledo, University of:** General[f]

**Tufts College:** Civil, electrical, mechanical

**Tulane University of Louisiana:** Civil, electrical, mechanical

**Tulsa, University of:** Petroleum (inculding options in refining and production)[c−r]

**Union College:** Civil, electrical

**United States Coast Guard Academy:** General[f]

**Utah State Agricultural College:** Civil

**Utah, University of:** Civil, electrical, mechanical, metallurgical, mining

**Vanderbilt University:** Civil, electrical, mechanical

**Vermont, University of:** Civil, electrical, mechanical

**Villanova College:** Civil, electrical, mechanical

**Virginia Military Institute:** Civil, electrical

**Virginia Polytechnic Institute:** Aeronautical, architectural, ceramic, chemical, civil (including sanitary option), electrical, industrial, mechanical, metallurgical, mining

**Virginia, University of:** Chemical, civil, electrical, mechanical

**Washington, State College of:** Architectural, civil, electrical, mechanical, metallurgical, mining

**Washington University:** Architectural, chemical, civil (including construction option), electrical, geological, industrial (administrative), mechanical

**Washington, University of:** Aeronautical, ceramic, chemical, civil, electrical, mechanical, metallurgical, mining

**Wayne University:** Civil, electrical, mechanical

**Webb Institute of Naval Architecture:** Naval architecture and marine engineering

**West Virginia University:** Chemical, civil, electrical, mechanical, mining

**Wisconsin, University of:** Chemical, civil, electrical, mechanical, metallurgical, mining

**Worcester, Polytechnic Institute:** Chemical, civil, electrical, mechanical

**Wyoming, University of:** Civil, electrical, mechanical

**Yale University:** Chemical, civil, electrical, mechanical, metallurgical, (metallurgy)

## List of Accredited Curricula of Technical Institute Type

**Academy of Aeronautics** (LaGuardia Field, N. Y.): Aircraft design and construction (resident full-time programs and resident part-time evening programs), aircraft mechanics and maintenance (resident full-time and resident part-time evening programs)

**The Aeronautical University** (Chicago, Ill.): Aeronautical engineering drafting

**Bliss Electrical School** (Washington, D. C.): Fundamentals of industrial electrical engineering

**Bridgeport Engineering Institute** (Bridgeport, Conn.): Mechanical engineering,* electrical engineering*

**Capitol Radio Engineering Institute** (Washington, D. C.): Residence course in practical radio engineering, correspondence course in practical radio engineering

**Franklin Technical Institute** (Boston, Mass.): Industrial electricity, industrial chemistry

**Franklin University** (Columbus, Ohio): Radio-electronics-television, refrigeration-air conditioning

**Milwaukee School of Engineering** (Milwaukee, Wis.): Electrotechnician, electronics technician, radio technician

**Northrup Aeronautical Institute** (Hawthorne, Calif.): Aeronautical engineering*

**Ohio Mechanics Institute** (Cincinnati, Ohio): Industrial engineering*

**R. C. A. Institutes** (New York, N. Y.): Advanced technology course (radio communication and sound and television)

**Wentworth Institute** (Boston, Mass.): Machine construction and tool design, steam and Diesel engineering, architectural construction, electrical construction

*It should be noted that titles of curricula offered by technical institutes are sometimes the same as the titles commonly used to designate professional curricula given by degree-granting engineering colleges, although the purpose and scope of the two types of program are not the same. The curriculum listed herein has been accredited as a program of technical institute type.

(*Continued from page 86*)

administered as a department of the United Engineering Trustees, Inc. The survey is being financed by a grant from the Engineering Foundation and it is being made by Richardson King Wood. Members of the survey committee are: Ole Singstad, chairman, Frank T. Sisco, George Sutherland, James S. Thompson, Jerome K. Wilcox, Robert H. Barclay, and Ralph H. Phelps.

As a part of the program to increase the usefulness of the Engineering Societies Library, the United Engineering Trustees, Inc, has reduced the size of the library board from 22 to 12 so that it can act more quikly and easily. The members of the board for 1948–1949 are: James S. Thompson, chairman; Frank T. Sisco, vice-chairman; Harold M. Lewis; W. N. Carey; James Douglas; James L. Head; Professor Theodore Baumeister; Professor H. M. Turner; George Sutherland; K. W. Jappe; E. C. Meagher; Ralph H. Phelps, secretary.

**Power Conference Set for Spring.** The 11th annual Midwest Power Conference will be held April 18–20, 1949, at the Sherman Hotel, Chicago, Ill. Principal sessions will be centered around the theme, "How to Better Supply Power Needs in Periods of Declining Resources." The meeting is sponsored by the Illinois Institute of Technology with the co-operation of 18 midwestern universities and professional societies. It has attracted well over 2,500 engineers each year. Co-operating institutions include Iowa and Michigan State Colleges, Northwestern and Purdue Universities, the Universities of Iowa, Illinois, Michigan, Minnesota, and Wisconsin, the Western Society of Engineers, Engineers' Society of Milwaukee, National Association of Power Engineers, the Illinois chapter of the American Society of Heating and Ventilating Engineers, the Illinois section of the American Society of Civil Engineers, and the Chicago Sections of the AIEE, American Institute of Chemical Engineers, American Institute of Mining and Metallurgical Engineers, and American Society of Mechanical Engineers.

# LETTERS TO THE EDITOR

**INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.**

## Internal Impedance

*To the Editor:*

Damper bars in synchronous machines and the cage bars in induction machines frequently have cross sections shaped to emphasize "skin effect." The internal impedance of a bar having a cross section like that in Figure 1 is computed readily by a formula that is derived by using complex hyperbolic functions. The application of the functions of complex hyperbolic angles to this problem is developed in "Heat losses in the Conductors of Alternating-Current Machines," by W. V. Lyon, AIEE *TRANSACTIONS*, volume 40, 1921, pages 1361–1409. The following analysis is a continuation of the method used in that paper. The complex angular depth, $\Theta$, of a solid rectangular conductor is

$$\Theta = \alpha d = 2\pi d\sqrt{\frac{2f}{\rho}}/45°$$

where $d$ is the depth of the conductor in centimeters, $f$ is the frequency, and $\rho$ is the resistivity in centimeter-gram-second units. At 100 degrees centigrade, $\rho$ for copper = 2,240. Let

$$M = \Theta \coth \Theta = M_r + jM_x$$

and

$$N=\Theta\, 2\tanh\frac{\Theta}{2}=N_r+jN_x$$

If $R_1$ is the d-c resistance of section 1 and $R_2$ is the d-c resistance of section 2 the resistance drop at the top of the lower section 1 is

$$I_1M_1R_1 \qquad (1)$$

(Equation 7a page 1375, AIEE *TRANSACTIONS*, volume 40, 1921, with $I_0=0$).

In equation 3, page 1369, $A$ is the current density at the bottom of a conductor which carries a current $I_1$ and which has a current $I_0$ below it. Multiply the equation for $A$ by $\rho_2\frac{d_2}{d_2}$ and change $I_1$ to $I_2$ and $I_0$ to $I_1$ and obtain

$$\rho_A=\frac{\rho_2}{w_2d_2}\left\{\frac{I_2\alpha_2d_2}{\sinh\alpha_2d_2}-I_1\alpha_2d_2\tanh\frac{\alpha_2d_2}{2}\right\}$$

Consequently the resistance drop at the bottom of the upper section 2 is

$$R_2\left(I_2\frac{\Theta_2}{\sinh\Theta_2}-I_1\frac{N_2}{2}\right) \qquad (2)$$

The voltages, equations 1 and 2, are equal and hence the relation between $I_1$ and $I_2$ is established.

Thus

$$I_2=\frac{\sinh\Theta_2}{R_2\Theta_2}\left(I_1M_1R_1+I_1R_2\frac{N_2}{2}\right) \qquad (3)$$

The voltage at the top of the upper section 2 is (equation 7a with $I_1=I_2$ and $I_0-I_1$)

$$E=R_2\left(I_2M_2+I_1\frac{N_2}{2}\right) \qquad (4)$$

The total current is

$$I=I_1+I_2$$

Therefore the internal impedance of the entire bar is

$$Z=\frac{E}{I}=\frac{R_2\left(I_2M_2+I_1\frac{N_2}{2}\right)}{I_1+I_2} \qquad (5)$$

Substitute the value of $I_2$ in terms of $I_1$ in this expression for the internal impedance and reduce the expression to its simplest form by combining terms.

$$Z=\frac{R_1M_1\times R_2M_2+jR_2^2|\Theta_2|^2}{R_1M_1+R_2M_2} \qquad (6)$$

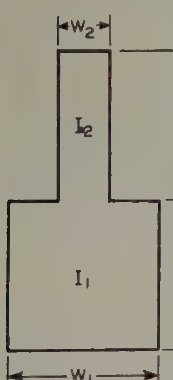



**Figure 1**

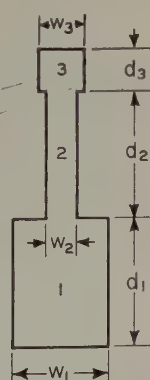



**Figure 2**

If $\frac{R_2}{R_1}=\frac{A_1\rho_2}{A_2\rho_1}=b$, the internal impedance becomes

$$Z=\frac{M_1\times M_2+jb|\Theta_2|^2}{M_1+bM_2}(1+b)R_0 \qquad (7)$$

where $R_0$ is d-c resistance of the entire conductor.

A table of $M_r$ and $M_x$ for different values of $|\Theta|$ is given to aid in computing the internal impedance. The following numerical example is taken from "Starting Performance of Synchronous Motors," H. V. Putnam, AIEE *JOURNAL*, 1927, pages 794–801.

Let $w_1=0.477$ centimeter, $d_1=0.715$ centimeter, $w_2=0.159$ centimeter, $d_2=0.715$ centimeter

$$\Theta_1=2\pi d_1\sqrt{\frac{120}{2{,}240}}=1.04 \qquad b=\frac{0.477\times0.715}{0.159\times0.715}=3$$

$$\Theta_2=2\pi d_2\sqrt{\frac{120}{2{,}240}}=1.04$$

$$M_1=M_2=1.026+j0.3586 \qquad |\Theta_2|^2=1.0816$$

$$Z=\frac{(1.026+j0.3586)(1.026+j0.3586)+j3\times1.0816}{(1.026+j0.3586)+3(1.026+j0.3586)}(3+1)R_0$$

Since $M_1=M_2$ in this example

$$Z=\left(1.026+j0.3586+j\frac{3.2448}{1.026+j0.3586}\right)R_0$$
$$=(2.01+j3.18)R_0$$

By a somewhat different method which requires considerably more computation, Putnam obtains

$$Z=(1.98+j3.19)R_0$$

A common type of cast rotor bar might be considered, as an approximation, to consist of three rectangles as in Figure 2. If the d-c resistance of the two lower sections (1 and 2) in Figure 2 is $R_0$ their internal impedance is $K_{12}R_0$ where $K_{12}$ is defined in equation 7. Equation 1 shows that the internal impedance of the lower section (1) of the bar in Figure 1 is $M_1R_1$. By noting how this impedance, $M_1R_1$ occurs in equation 6, we at once can write the expression for the internal impedance for the entire bar in Figure 2. It is

$$Z=\frac{K_{12}\times M_3+j\frac{A_1+A_2}{A_3}|\Theta_3|^2}{K_{12}+\frac{A_1+A_2}{A_3}M_3}\left(1+\frac{A_1+A_2}{A_3}\right)R$$

where $A_1$, $A_2$, $A_3$ are the areas of the three sections of the bar and $R$ is total d-c resistance. Also, $\Theta_3$ and $M_3$ are computed for the top section (3) of the bar. If there is no conductor in the space 2,

$$k_{12}=M_1+j8\pi^2f\frac{d_2}{w_2}\frac{w_1d_1}{\rho_1}$$

Equation 6 also can be used to compute the internal impedance of a round wire which has a thin coating of a different material. If the thickness of the coating is very small compared with the radius of the wire, the true Bessel's function solution substantially equals the hyperbolic solution.

Thus the internal impedance, Z, of the coated conductor is

$$Z=\frac{Z_1\times RM+jR^2|\Theta|^2}{Z_1+RM}$$

where $Z_1$ is the internal impedance of the uncoated conductor computed by any convenient method. For example, see L. F Woodruff, "Principles of Electric Power Transmission," page 61. Also $R$ is the d-c resistance of the coating and $d$, $\mu$, $\rho$ are the thickness, the permeability, and the resistivity of the coating.

$$\Theta=2\pi d\sqrt{\frac{2f\mu}{\rho}}\ \underline{/45^\circ}$$

$$M=\Theta\coth\Theta$$

**Table of Complex Hyperbolic Function $M_r+jM_x$**

| $\lvert\Theta\rvert$ | $M_r$ | $M_x$ | $\lvert\Theta\rvert$ | $M_r$ | $M_x$ |
|---|---|---|---|---|---|
| 0.1 | 1.000 | 0.0029 | 1.8 | 1.213 | 1.015 |
| 0.2 | 1.000 | 0.0134 | 1.9 | 1.258 | 1.116 |
| 0.3 | 1.000 | 0.0300 | 2.0 | 1.309 | 1.216 |
| 0.4 | 1.0006 | 0.0533 | 2.1 | 1.366 | 1.318 |
| 0.5 | 1.0014 | 0.0832 | 2.2 | 1.427 | 1.419 |
| 0.6 | 1.0027 | 0.1199 | 2.3 | 1.493 | 1.519 |
| 0.7 | 1.0053 | 0.1632 | 2.4 | 1.564 | 1.617 |
| 0.8 | 1.0090 | 0.2126 | 2.6 | 1.714 | 1.805 |
| 0.9 | 1.0145 | 0.2687 | 2.8 | 1.874 | 1.982 |
| 1.0 | 1.022 | 0.3312 | 3.0 | 2.040 | 2.147 |
| 1.1 | 1.032 | 0.3996 | 3.2 | 2.205 | 2.301 |
| 1.2 | 1.045 | 0.474 | 3.6 | 2.527 | 2.587 |
| 1.3 | 1.062 | 0.554 | 4.0 | 2.833 | 2.856 |
| 1.4 | 1.085 | 0.650 | 4.5 | 3.193 | 3.193 |
| 1.5 | 1.108 | 0.727 | 5.0 | 3.546 | 3.537 |
| 1.6 | 1.137 | 0.820 | 6.0 | 4.246 | 4.243 |
| 1.7 | 1.172 | 0.917 | | | |

In this table the error in straight-line interpolation is less than 0.1 per cent.

For small values of $|\Theta|$, less than 0.4, $M_r=1.0$ and $M_x=\frac{|\Theta|^2}{3}$. The error is $<0.1$ per cent.


WALDO V. LYON (F '33)

(Department of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass.)


## English for Engineers

*To the Editor:*

Since I was old enough to misspell "synchronous" I have been reading about and listening to my "older brothers" and their expoundings upon the need for better expression among students.

This continuing conflict has long reminded me of a fable about a bear and a lion who were arguing over the predicament of a rabbit who was about to be devoured by a wolf. Both the bear and the lion were sure that something should be done, but they could not agree that the other's plan was good enough. The rabbit, who by that time was past saving, would have been glad to accept either of the solutions.

It seems to me that while the "sages" gnash their teeth and scowl at each other over the students' plight, while they call upon "informed men" to bear out their arguments, and while they expound the disadvantages of suggestions by others, they might for a moment consider us "rabbits."

Although we possibly may not have the necessary knowledge of engineering to judge, as H. H. Ketcham says of Professor A. L. Muir (*EE, Nov '48, p 1130*), we are, like the rabbit, somewhat concerned. Con-

sequently, if they can take time out for a moment, possibly the "bears" and the "lions" might do one thing for us.

One thing students would enjoy most is some good expression in the textbooks our benefactors write for "us." We have come to agree wholeheartedly with Mr. Ketcham when he says most engineers write for themselves. After plodding through some of these so-called textbooks for several years, one becomes indoctrinated with that style (?) of writing (?). How can any more be expected of us?

Now, after all, there has been enough written about our need for better expression to fill a library. I doubt if anything new has been said for some time. So, considering the moral of the fable, why not compromise and at least do something?

JOHN W. HUSTON

(Student Member, AIEE; electrical engineering student, Iowa State College of Agricultural and Mechanic Arts, Ames, Iowa)

## Origin of the Electric Motor

*To the Editor:*

The following comments are provoked by the article, "Origin of the Electric Motor," by Joseph C. Michalowicz (*EE, Nov '48, pp 1035–40*). I believe these remarks will add to the great interest which many of us have in Professor Michalowicz's article.

I have, in my library, a 3-volume set of books entitled "Electricity in Every-Day Life," the author being the late Doctor E. J. Huston whose name was so well known in my boyhood days in connection with all outstanding matters pertaining to electrical engineering. On page 398 of volume 2 of these books, I find Figure 227 (Figure 1 of this letter) and the following quoted information:

"In 1834, Ritchie, in America, invented the form of electromagnetic motor shown in Figure 227 (Figure 1). Here the field magnet consists of a permanent magnet *NS*, in the shape of a horseshoe. The armature is formed by an electromagnet, *AB*, wrapped with coils of insulated wire, and so mounted as to be capable of rotation on a vertical axis above the poles *N* and *S* of

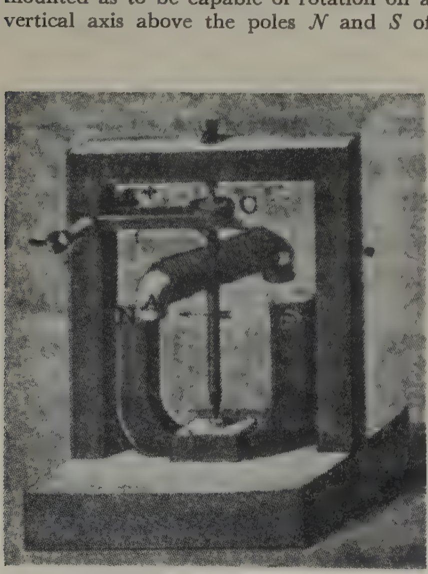


Figure 1

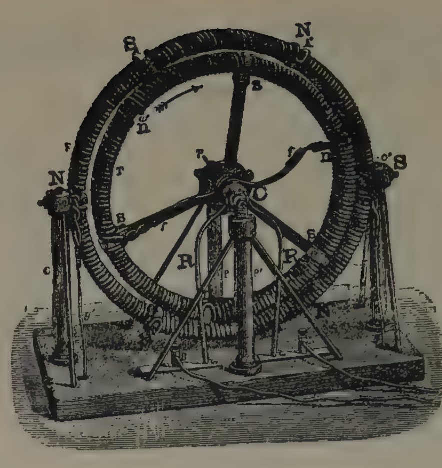


Figure 2

the field magnet. A commutator at *C* changes the direction of the current twice during each complete rotation. If the circuit connections are such that, in the position shown in the figure, the *A* pole of the armature is made to acquire south magnetic polarity, and *B* north magnetic polarity, then the mutual attraction between the poles of the armature and the field will cause the armature to move in the direction indicated by the arrow. But at this moment the direction of the current through the coils on the armature is reversed, so that the poles of the armature now become of the same polarity. Since the momentum, or tendency of the armature to keep on moving, carries it a short distance past the poles of the field magnet, the motion is continued by the repulsion between these poles, which causes it to rotate until the pole *A* is brought within the attractive influence of *S*, and *B* within the influence of *N*. In this manner a continuous rotation is effected. The commutator *C* is employed for changing the direction of the current."

Again on page 400, I find Figure 228 (Figure 2 of this letter) and the following:

"In 1843, Elias, of Haarlem, invented a form of electric motor which showed various marked improvements over pre-existing forms. The Elias motor is shown in Figure 228 (Figure 2). Here the field magnets consist of a circular ring of soft iron. This ring was wrapped with coils of insulated wire, so that, when traversed by a current, it produced six poles of alternately opposite polarity, at *N, S, N, S, N, S*. The armature consisted of a similar iron ring wound with coils of insulated wire, so as to produce six magnet poles of alternately opposite polarity, at *n, s, n, s, n, s*. The armature was mounted on a horizontal axis, so as to be capable of rotation within the field magnets. The Elias motor, like that of Jacobi, employed electromagnets both for the field and the armature. It was, as will be seen, a sexti-polar machine; that is, one whose field magnets consist of six separate magnet poles. The commutator *C* was employed for changing the polarity of the armature coils at the proper moment, in order to permit continuous rotation. It differed also in that it formed a motor in which the field magnets were separately excited, a separate and distinct battery being employed for maintaining the magnetism of the field magnet."

It seems quite evident from Professor Michalowicz's article and the quoted articles, that many persons of the time described were alert in attempting to apply Faraday's discovery of the relation between motion of a magnetic field and the generation of electric current. The experimenters mentioned, like many who have followed them, were prevented from putting their ideas into commercial operation by a lack of the right kind of materials.

The Elias motor shown in Figure 228 (Figure 2) is of particular interest because, like the motor of De Jacobi shown in Figure 4 of Professor Michalowicz's article, it had electromagnets for both field and armature.

R. W. SORENSEN (F '19)

(Professor of electrical engineering, California Institute of Technology, Pasadena, Calif.)

## Electrical Essay

*To the Editor:*

The network in Doctor Slepian's most recent electrical essay (*EE, Dec '48, p 1141*) is of particular interest since it exhibits a steady-state impedance equal to *R* for any frequency of applied voltage. Furthermore, no transients are measurable externally when voltage from a source of negligible impedance suddenly is applied. However, the transient response of the network is not identical with that of a simple resistance when the external circuit contains appreciable impedance.

For instance, if a direct voltage *E* suddenly is applied to the box with the network through an external resistance $R_1$, the transient response will be

$$i=\frac{E}{R+R_1}\left[1+\epsilon^{-\frac{t}{(R+R_1)C}}-\epsilon^{-\frac{R+R_1}{R^2C}t}\right]$$

*L* has been eliminated using the given relation:

$$R=\sqrt{\frac{L}{C}}$$

It will be noted that the transient terms do not cancel each other except when $R_1=0$. The response of the box containing the resistance alone would be, of course,

$$i=\frac{E}{R+R_1}$$

without any transient.

If $R_1$ is large with respect to *R*, the second transient term will die away so rapidly with respect to the first transient term that it would be possible to determine the time constant $(R+R_1)C$ from an oscillogram of the current, and thus find the value for *C*. The inductance then would be found from the relation $L=R^2C$.

Discharging a capacitor through the network also will result in a current transient different from that obtained when discharging through the simple resistance. In fact, if the external capacitance $C_1$ is less than four times the internal capacitance *C*, there will be an oscillatory component in the transient having an angular frequency:

$$\omega=\frac{1}{\sqrt{LC}}\sqrt{\frac{C}{C_1}-\frac{1}{4}}.$$

W. M. LEEDS (M'38)

(Westinghouse Electric Corporation, East Pittsburgh, Pa.)

## Engineering Association

*To the Editor:*

The 1946 report of the Institute's subcommittee on professional activities proposed the formation of the American Engineering Association to satisfy the craving of engineers for an organization, similar to the American Medical Association and the American Bar Association, to be dedicated to the promotion of the professional, social, and economic interest of engineers. The report summarized the views of the committee, and set forth the outline of a suggested constitution for the association (*EE, May '47, pp 496–501*).

In an address presented in November 1947, at a joint session of the AIEE and the National Electronics Conference, B. D. Hull, then president of the Institute, proposed that a constitutional convention be held, to adopt a constitution and to effect an organization. The address was published in *ELECTRICAL ENGINEERING* (*EE, Apr '48, pp 313–15*) and Mr. Hull stated that "comments, ideas, and criticisms will be welcome." Several responses already have appeared as "letters to the editor."

After careful study of the report and of Mr. Hull's address, and after doing some collateral reading, I see more and more justification for a thorough airing of the subject. At the outset, we should recognize, and be grateful for, the great amount of work done by the 1946 AIEE subcommittee and its predecessors, as well as by the joint efforts and deliberations of contemporary committees of other engineering societies. The report culminates some 30 years of discussions, and at last boils the matter down to a relatively few fundamental considerations expressed in black and white. Whether we should endorse the proposals, or adopt some alternative course to achieve the desired goal, is the question before us.

As professional engineers, we all are agreed that we should have an organization to promote our professional, social, and economic interests, as distinguished from our technical interests. With that in mind, we should examine the present proposals carefully and, above all, objectively. Each engineer must decide for himself whether or not he would want to join the American Engineering Association if it were organized substantially in accordance with the proposed constitution. We also should not overlook the prospects of getting all of the technical engineering societies to subscribe to the venture.

*Objectives.* First, let us examine the objectives of the association. As stated in the proposed constitution:

> The association's principal objectives, briefly stated, should be the maintenance of high professional standards among its members, the advancement of standards of engineering education, the enhancement of professional recognition and status, and the stimulation of engineers to take their proper place—individually and collectively—in public affairs. In addition, the association shall aid and encourage, principally through its affiliated societies, the advancement of the theory and practice of engineering in its several branches.

As far as electrical engineers are concerned those objectives appear to offer little, if anything, more than already is offered by the AIEE. Its constitution states that the objects of the AIEE

> ... shall be the advancement of the theory and practice of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members.

Both of these constitutional provisions cover the same ground. There is merely a change of emphasis introduced by reversing the order of the phrases.

Other than adopting a code of ethics, to maintain a high professional standing among its members, the Institute, like the other technical societies, has been reluctant to do anything directly toward promoting the professional, social, or economic interests of its members. Our present purpose is to establish an organization which, first, will do things that the technical societies do not do and, second, not attempt to do what the technical societies are so well equipped to do in their respective fields.

"*Over-All.*" It is proposed that we should have an "over-all" association composed of both technical societies represented by elected delegates on a proportional basis, and individual members. The technical engineering societies are admittedly ill-adapted to cope with the professional aspects of engineering, and there is no assurance that they would contribute anything of value if they were admitted to the councils of the "over-all" association.

The professional organization of engineers should be composed exclusively of individual members. There should be neither pressure blocs, nor doubling or trebling of voting strength through membership in one or more technical societies.

Certainly, no technical society wants to surrender one bit of its autonomy to an "over-all" association. Yet, Mr. Hull has said, in his address, that "a set of uniform grades and qualifications for membership *must* be adopted by all participating societies..." Not all of the existing technical engineering societies have the grade of Fellow. "Why bring that up?" Only an atomic bomb could have greater explosive potentialities. I am old enough to recall something of how the introduction of the grade of Fellow was received in the AIEE about 35 years ago. It almost resulted in mass resignations. Many distinguished Members, who were eminently qualified to be Fellows, were so incensed at being deprived of even one of their rights as Members that they steadfastly refused to transfer to the grade of Fellow as long as they lived.

It is entirely unnecessary for the professional organization of engineers to meddle in the internal affairs of the technical societies, unless those societies intrude and submit to the superauthority by becoming affiliated in the—shall we say, "ueber-alles"—association, as contemplated in the proposed constitution.

*Grades of Membership.* The proposed constitution calls for five grades of individual members. Besides Fellows, Members, Associates, and Students, it would have a grade of "Affiliate" for persons "engaged in some phase of recognized engineering activity, but who cannot qualify for another grade of membership." How could an organization of such heterogeneous membership be expected to foster the interests of professional engineers? And how much of profit or prestige would a reputable professional engineer gain by joining it?

If we are to have a professional organization comparable to the medical association and the bar association, it must be composed exclusively of registered professional engineers. To be accepted as a member will be ample mark of distinction, without any ornamentation by grades. All members must have equal rights and equal privileges.

*Qualifications for Membership.* All of our 48 states now have laws requiring registration in order to practice some or all branches of professional engineering, and it will not be long before all the states will require registration in order to practice in any branch.

In granting a certificate of registration, or a license to practice, the state certifies that the licensee is a qualified professional engineer. Having a license to practice is the first prerequisite among the qualifications for membership in a medical society or bar association. The standards of the professional organization of engineers should be no lower than those of the highest ranking professions, if we hope to attain their stature.

*Organization.* The American Bar Association and the Washington State Medical Association both held meetings in Seattle recently. Both received plenty of coverage in the local press, indicating the type of their organizations and how they function. We should be guided by the example and experience of those associations, in shaping our organization for professional engineers.

*Action.* After having talked for 30 years, more or less, about organizing the engineering profession, what are we going to do about it? Shall we endorse the plan to go ahead with a constitutional convention and try to organize, facing all of the controversial issues that I have mentioned, and many more? Shall we attempt to launch a new organization to compete with one which already is established and growing rapidly? I refer to the National Society of Professional Engineers.

*National Society of Professional Engineers.* The constitution of the National Society of Professional Engineers states that:

> The objects of the society shall be the advancement of the public welfare and the promotion of the professional, social and economic interests of the professional engineer.

That, it seems to me, expresses concisely and exactly the objectives which we have been striving to attain. It is broad enough to permit any essential activity, but does not commit the society to engage in extraneous projects.

The society was founded in 1934, and now has more than 18,000 members. The Washington Society of Professional Engineers is one of 20 or more state societies which comprise the national society. The Washington Society is incorporated under the laws of the State of Washington, and is autonomous, subject only to compliance with the constitution of the national society.

I am neither a member of the national society nor of the state society, so I am not soliciting members.

In closing, I simply commend, for serious consideration, the existing National Society of Professional Engineers as a likely means of fulfilling the desire for an organization dedicated to the promotion of the professional, social, and economic interests of engineers.

LLOYD N. ROBINSON (F'25)

(Puget Sound Power and Light Company, Seattle, Wash.)

## Dimensions of Resistivity

*To the Editor:*

J. W. Williamson's letter in the November issue of *ELECTRICAL ENGINEERING* (*p 1129*) on the dimensions of resistivity was very interesting. However, I feel he failed to bring out one point on the subject. Even more common than ohm-inches or ohm-centimeters, is the term, ohms per circular mil foot, as an expression for resistivity.

Starting with the basic formula for the resistance of a conductor:

$$R=\rho\frac{L}{A}$$

Where $R$ is the d-c resistance in ohms, $L$ the length in feet, $A$ the area in circular mils, and $\rho$ the resistivity in ohms per circular mil foot: the result of expressing this formula dimensionally is

$$\text{ohms}=\frac{\text{ohms}}{\text{circular mil}\times\text{feet}}\times\frac{\text{foot}}{\text{circular mils}}$$

$$=\frac{\text{ohms}}{(\text{circular mils})^2}$$

Obviously there is something wrong with the method used here to express resistivity. This point originally was raised in a senior class in transmission line theory, at Pratt Institute. Yet after seeing the error caused by applying dimensional analysis to the problem, none of the class was able to account for why the term, ohms per circular mil foot, is used. Solving dimensionally for $\rho$ gives

$$\rho=R\frac{A}{L}=\text{ohms}\times$$

$$\frac{\text{circular mils}}{\text{foot}}=\text{ohm-circular mils per foot}$$

Perhaps one of your readers can enlighten me on the subject.

WILLIAM E. WARDEN

(Student, engineering school, Pratt Institute, Brooklyn, N. Y.)

## European Engineering Practices

*To the Editor:*

I read with great interest in the September 1948 issue of *ELECTRICAL ENGINEERING* the article entitled "European Engineering Practices," by M. J. de Lerno and F. V. G. Bird (*pp 835–42*).

I have observed, however, that some of the information supplied by the authors of this article does not give sufficient consideration to French practice although the latter has been sanctioned by the operation of a very important system which includes at the present time, to mention only the field of very high voltages, more than 2,500 miles of 220-kv lines and more than 4,300 miles of 150-kv lines.

I do not wish to go in detail into all the parts of the afore-mentioned article, however I would like to draw attention to the technical problems for which the French solutions differ more widely from those described by the authors of the article as representing "European practice."

*Grounding of Neutrals.* All French systems having a higher voltage than 60 kv (90–150–220 kv) are operated with a solidly grounded neutral and this practice has been carried out ever since they were put under operation which for some of them goes as far back as 25 years or so. Operation of the 220-kv system with an insulated neutral and arc-extinguishing coils had been contemplated at a certain time but never has been tried out and this idea has been abandoned completely.

For transmission and distribution systems with a voltage equal at the most to 60 kv, solid grounding of the neutral is the technique most often resorted to; there exist however a few systems the neutral of which is grounded either through reactance coils of mean value, or through arc-extinguishing coils. Operation with a completely insulated neutral is limited to a certain number of distribution systems with a mean voltage supply.

*Interconnection — Short-Circuit Currents—Stability.* Interconnection between all parts of the French system has been total for the last ten years. The observed maximum peak load has exceeded 5 million kw in January 1948, which figure is on a level with those recorded on the great American systems (excepting the interconnection between the Great Lakes and the Gulf of Mexico). This entails that short-circuit currents reach constantly increasing values, so that the new types of 220-kv circuit breakers now being set up will have an interrupting capacity of 5 million kva.

The 220-kv transmission distances are about 300 miles in the United States, and stability problems are the same for both countries.

*Thermic and Hydro Power.* Yearly hydro power production in France represents 50 to 55 per cent of the total production. France possesses and has harnessed a certain number of high heads equipped with Pelton turbines, but the majority of hydro power plants dispose only of mean or low heads and are equipped with Francis or (for very low heads) Kaplan turbines.

*Hydrogen-Cooled Generators.* A hydrogen-cooled 30,000-kva synchronous condenser has been in operation in France for the last 15 years; several outdoor-type air-cooled 20,000-kva synchronous condensers have been built. At the present time all high-power turbogenerators (particularly the standardized 100,000-kw type) which are being built are hydrogen-cooled.

*Circuit Breakers.* Extra-high-voltage circuit breakers utilized in France are of the oil-poor and air-blast types.

Even with oil circuit breakers a compressed air control is sometimes utilized.

Single-pole automatic reclosure now is being tried out on several sections of the very-high-voltage system.

*400-Kv Transmission.* Important tests have been carried out in France for the last two years with the aim of studying the behavior of 400-kv lines, especially from the point of view of the corona effect and of comparing the different types of conductors to be utilized to this end (bundle of two conventional 220-kv conductors or single large diameter expanded conductors). These researches carried out at the 500-kv experimental station of Chevilly, have made the object of several technical communications (see, in particular: "Results of Tests Carried Out at the 500-kv Experimental Station of Chevilly (France) Especially on Corona Behavior of Bundle Conductors, François Cohen, in AIEE *TRANSACTIONS*, volume 67, 1948).

*Relay Engineering.* The fact that French systems for the most part are operated with grounded neutral, inspires the use of line protections sensitive to phase-to-ground faults.

The methods in more general use for high voltages are

1. Carrier current protection which equips all the 220-kv lines and part of the 150-kv lines. This kind of protection has been used in France for the last 18 years; almost all existing installations are of the directional carrier current interlock device type. The use of current phase comparison electronic devices now is being developed. All these protections are sensitive to phase-to-ground and phase-to-phase faults.
2. Ground directional watt relays protection.
3. Distance relays protection.

*Voltage Regulators.* Most voltage regulators at the present time belong to the rheostatic type, but part of the high-power alternators now being built will be provided with statis regulators combined with amplidynes controlling the field of exciters.

I think the data given in the foregoing will prove a useful complement to the information contained in the article of Messrs. de Lerno and Bird who, perhaps, have carried a bit far their generalizations based on the otherwise highly interesting observations they have been able to make.

P. AILLERET (M '46)

(Directeur des études and recherches de l'Electricité de France, Paris, France)

*To the Editor:*

Thanks to the recent article of M. J. DeLerno and F. V. G. Bird, the readers of *ELECTRICAL ENGINEERING* had an opportunity to get a clear picture of the development of European electrification.

They also were informed, in connection with the old idea of the 50-cycle railway traction, that the French State Railways intend to continue in the future the electrification of their lines with the 50-cycle single-phase system instead of the hitherto employed 1,500-volt direct current. To prepare this development they ordered three trial locomotives from three different firms. In this connection, a fact which was not mentioned in the afore-mentioned article would arouse some interest, namely that the Hungarian State Railways in 1932 already had electrified their most important (190 kilometers long) international railway line with the 50-cycle system and, in view of the excellent operating results, further electrification planned for the coming years also will be carried out with the same system. The electrified line is fed through simple transformer substations directly from the industrial high-voltage network, and for traction purposes 32 electric locomotives of the Kando system were built. The 2,500-horsepower electric locomotives now operating and their latest development are described in full in CIGRE (International Conference on Large Electric High-Voltage Systems) reports number 18, 1933; number 143, 1935; and number 321, 1948.

The Hollenthal experiments and the

ench locomotive orders prove that various utions are possible for the 50-cycle tracn. One of the possible solutions is the ndo system, and the 16-year old Hunrian electric traction has given practical idence that it meets all the requirements of ilway operation.

P. SZTROKAY

(Ganz and Company, Budapest, Hungary)

## n Electrical Problem

*o the Editor:*

With reference to "An Electrical Probm" of the August issue (*EE, Aug '48, pp 33–4*), the only difficulty seems to be in taining a consistent point of view. In the pen-delta secondary transformer connecon, Messrs. Ferguson and Thomas have ated that $Eab = E_e{}^{j60}$ and $Ebc = E_e{}^{-j60}$. onsidering that the primary is in the quence *Eab-Ebc-Eca*, then this sequence ust be maintained in solving the secondary oltages. The problem, therefore, is not of

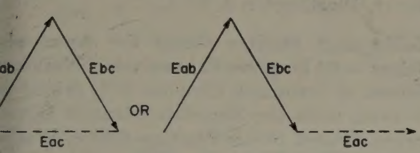



Figure 1

nding what phase relation the resultant oltage *Eac* is, but rather of what phase is e voltage *Eca*. This is given by vector ddition to be $Eca = ECb + Eba = E_e{}^{j180}$. This the correct result necessary for 3-phase peration of the open-delta secondary. he conclusion of Messrs. Ferguson and homas might be expressed in a vector agram as shown in Figure 1. These agrams demonstrate the erroneous innsistency.

WESLEY G. NILSON

tudent Member, Bucknell University, Lewisburg, Pa.)

*o the Editor:*

The problem submitted by Ferguson and homas in the August issue of *ELECTRICAL NGINEERING* is a subtle one. Its lution is simple enough if one keeps conentional vector rules in mind.

I believe that Messrs. Ferguson and homas mean that $Eac = Ecx$ in magnitude nly. Quoting: "With the coils connected shown, equal voltage will be read between c and *Cx*, . . . ." Actually, $-Eac = Ecx = ca$, with coil *3* connected or omitted.

The phase rotation for the delta voltages ositive sequence) is *Eab*, *Ebc*, *Eca*, either ith coil *3* connected or omitted.

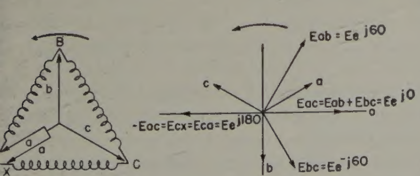



Figure 1

It is a fact that $Eac = Eab + Ebc$, but the sequence around the delta, closed or open, is $A \rightarrow B$, $B \rightarrow C$, and $C \rightarrow A$. The primary reason why the delta can be closed is that $Eab + Ebc = -Eca$; that is, no fundamental-frequency current can flow in the closed delta under normal balance voltage conditions, with balanced phase-to-phase impedance.

PAUL E. SHIELDS (M '45)

(Westinghouse Electric Corporation, Youngstown, Ohio)

*To the Editor:*

I wish to submit a discussion and suggest an answer to the problem submitted by S. A. Ferguson and G. S. Thomas, in the hope that it may clear up the confusion which apparently exists in the minds of those who submitted the problem.

It is indeed true that the resultant voltage of transformers *AB* and *BC* (Figure 1) is equal to *AC* both in phase angle and in numerical value. It is also true that the voltage of transformer *CX* is equal in numerical value but opposite in phase angle to (that is, 180 degrees in phase angle from) the resultant voltage AC.

This is necessarily so and when *X* and *A* are connected, the voltage *CX* is equal and opposite to *AC* so that the resultant voltage of the three transformers in delta is zero. Otherwise, there would be a local circulating current around the delta which would do no useful work in the external circuit, but

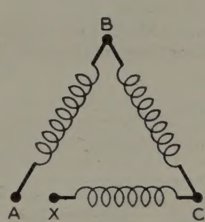



Figure 1

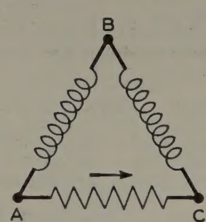



Figure 2

would result in high $I^2R$ loses in the transformer secondaries.

Consider the case of an open delta connection of transformers *AB* and *BC*, with a single-phase load *AC* (Figure 2) connected between the terminal *A* and *C* instead of the transformer *CX*. The resultant voltage *AC* of the two transformers would cause current to flow in the direction *AC*.

If the single-phase load *AC* were displaced to *A′C′* as in Figure 3, and connected as shown *A* to *A′* and *C* to *C′*, current still would flow through the load in the direction *A′C′*.

If now we replace the transformer *CX* of Figure 1 except that terminal *Y* is not connected to *C* even as *X* is not connected to *A* (we assume that the primaries of these transformers are still excited from a 3-phase source as in Figure 1), we find that the voltage *YX*, though 180 degrees out of phase with the resultant voltage *AC* (Figure 4), yet it delivers a current through the load in the same direction *A′C′*, as does the voltage *AC*.

It then appears that if a 3-phase delta-connected bank of transformers *AB*, *BC*, and *CA*, (Figure 5) the current would be in direction *A′C′*, but part of the load would

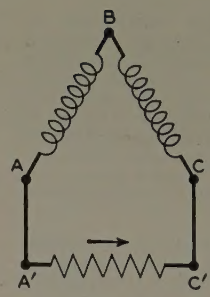



Figure 3

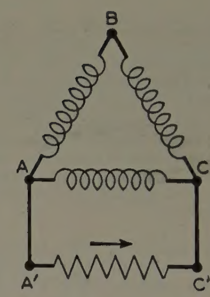



Figure 5

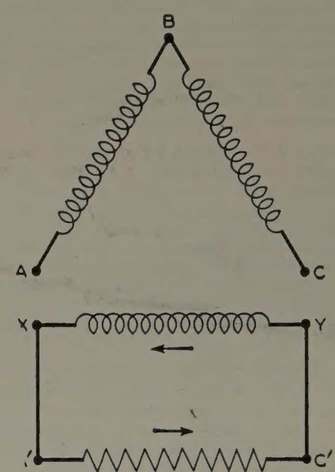



Figure 4

be supplied by transformer *AC* with its voltage in the direction *CA*, and part of the load by the resultant of *AB* and *BC*, in parallel with *CA*, but with the resultant voltage in the direction *AC*, opposed (around the delta) to *CA*.

H. P. HASTINGS

(Crouse-Hinds Company, Syracuse, N. Y.)

# NEW BOOKS • • • • •

**The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.**

ASM REVIEW OF METAL LITERATURE, volume 4, 1947. Edited by M. R. Hyslop. American Society for Metals, Cleveland 3, Ohio, 1948. 720 pages, 9¼ by 6 inches, fabrikoid, $15. This comprehensive survey of the metallurgical literature published during 1947 continues the useful series started in 1944. The brief abstracts indicate the scope and content. In addition to the main classified arrangement of the items, a detailed subject index and an author index are provided. The addresses of the journals and periodicals abstracted are given. Both American and foreign literature are covered in the more than 8,000 items included in the current volume.

ASTM STANDARDS ON PLASTICS. Sponsored by ASTM Committee D-20 on Plastics, September 1948, American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 595 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $4.50. Contains all of the 130 established and tentative specifications, methods of testing, and recommended practices for plastics issued by the American Society for Testing Materials. There are also five sets of definitions, a descriptive nomenclature of objects made from plastics, and a statement of the regulations governing the ASTM Committee on Plastics.

CALCULATION OF FAULT CURRENTS IN ELECTRICAL NETWORKS, CIRCUIT-BREAKER SELECTION. By R. T. Lythall. Second edition. Sir Isaac Pitman and Sons, Ltd., London, England, 1947. 77 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, 12s.6d. This introduction to the subject of circuit breaker selection sets out in simple language the methods of conducting calculations in a form easily understood, and presents them in such a way that they may be applied immediately without recourse to deep theory.

OPERATION AND MAINTENANCE OF INDUSTRIAL ELECTRIC MOTORS. By G. W. Stubbings. Third edition. E. & F. N. Spon, Ltd., 57 Haymarket, London, S.W.I., England, 1947. 176 pages, diagrams, charts, $7^1/_2$ by 5 inches, cloth, 10s.6d. Formerly "Diseases of Electrical Machinery," this edition has been revised and enlarged. The two opening chapters give a full but nonmathematical explanation of the action and normal operating characteristics of d-c generating plant and all classes of electric motors used for ordinary industrial purposes. Brief mention is made of simple electrical testing, and abnormal and faulty operation of electric machinery is considered in detail.

REPORTS ON PROGRESS IN PHYSICS. Volume 11 (1946–47). Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W. 7, England, 1948. 461 pages, illustrations, diagrams, charts, tables, 10 by 7 inches, cloth, £2 2s. plus postage 1s.; price to Fellows, 25s. plus postage 1s. Contains articles by outstanding men in the various fields. Such topics as electrostatic generators, radioactive branching, ferromagnetism, atomic structure, spectroscopy, ultrasonics, photography, thermionic emission, evaporation, and astronomy, are dealt with in detail.

SOME ASPECTS OF THE LUMINESCENCE OF SOLIDS. By F. A. Kröger. Elsevier Publishing Company, New York, N. Y.; Amsterdam, Holland; London, England; Brussels, Belgium, 1948. 310 pages, diagrams, charts, tables, $8^1/_4$ by 6 inches, cloth, $5.50. Based on recent experimental work, this book contains some hitherto unpublished results together with theoretical considerations of certain aspects of this field. Brief consideration is given to the energy levels in pure and disturbed crystals, a general picture is developed covering all possible luminescent effects, new experimental results are reported concerning some particular luminescent systems, and the influence of temperature on the efficiency of luminescence is considered.

TABLES OF PHYSICAL AND CHEMICAL CONSTANTS AND SOME MATHEMATICAL FUNCTIONS. By G. W. C. Kaye and T. H. Laby. Tenth edition. Longmans, Green and Company, London, England, New York, N. Y., and Toronto, Ontario, Canada, 1948. 194 pages, tables, $9^3/_4$ by $6^1/_4$ inches, cloth, $5.50. An up-to-date moderately priced collection of physical and chemical tables which will be of use in teaching and in the laboratory. In the tenth edition, the general constants of physics and astronomy have been revised; the absolute value of gravity recalculated; and the section on optical glass has been rewritten and expanded.

THEORY AND PRACTICE OF HEAT ENGINES. By R. H. Grundy. Longmans, Green and Company, London, England, New York, N. Y., Toronto, Ontario, Canada, 1947. 723 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $6. The theory section of this introductory text is developed from the basic principles and emphasizes its dependence on physics and chemistry. The practical section covers boilers, steam engines, steam turbines, and internal combustion engines. Descriptions of the latest plant are included with sectional views and photographs.

THERMODYNAMICS. By E. F. Obert. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, London, England, 1948. 571 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.50. Intended for use by engineering students, this fundamental text presents a comprehensive treatment of the subject. It provides certain essential material that must be understood by the practicing engineer, and considerable stress is placed upon real machines, flow processes, and the properties of fluids. It includes the concept of reversibility and dimensions and units.

YEAR BOOK OF THE HEATING AND VENTILATING INDUSTRY, 1948. Technitrade Journals, Ltd., 8 Southampton Row, London, W.C.1, England. 206 pages, illustrations, diagrams, $8^3/_4$ by $5^1/_2$ inches, cloth, 5s. Of interest to architects, consulting engineers, and those who deal with heating and ventilating contractors this compact volume contains technical, contractual, and trade information. In addition to articles on various phases of the field, there is a buyer's guide, and also lists of technical and trade associations, trade names, and the officers and members of the Association of Heating, Ventilating and Domestic Engineering Employers.

POWER AND PROCESS STEAM ENGINEERING. By D. Copp. Longmans, Green and Company, New York, N. Y.; Edward Arnold and Company, London, England, 1947. 173 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75. Of value to those interested in the efficient use of industrial fuel, this practical book presents the methods and principles of combined heat and power-producing installations. It emphasizes the fullest use of the latent heat of steam and describes systems which derive the most energy from fuel. Many charts and diagrams illustrate the text.

(THE) DIARY AND SUNDRY OBSERVATIONS OF THOMAS ALVA EDISON. Edited by D. D. Runes. Philosophical Library, 15 East 40th Street, New York, N. Y., 1948. 247 pages, illustrations, 9 by $5^1/_2$ inches, cloth, $4.75. Presents some of Edison's social and philosophical views by including a section of his diary of 1885 and other selections from his writings during the period 1921–1930. These include Edison's comments on the social effect of some of his inventions such as motion pictures and the phonograph and on such general topics as prevention of war, life after death, music, and education. The editor does not indicate the source of the material.

LES DIÉLECTRIQUES. By J. Granier, preface by J. Cabannes. Dunod, Paris, France, 1948. 215 pages, diagrams, charts, tables, $9^1/_2$ by $6^1/_4$ inches, paper, 620 frs. Discusses the relation of the properties of dielectrics to their chemical and physical makeup. The important dielectric losses are explained in detail, and industrial insulators and insulating mediums are considered briefly.

ELEMENTARY STEAM POWER ENGINEERING. By E. MacNaughton. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd. London, England, 1948. 640 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6.50. Presents in a clear and concise manner the fundamental principles underlying the construction and operation of steam power plants and equipment. New data on thermodynamic principles, turbines, and boilers have been added to this edition, while the remaining material has been thoroughly revised and brought up to date. As in previous editions, practical applications have been introduced before discussions of the theoretical aspects.

(The) METRIC SYSTEM OF WEIGHTS AND MEASURES. The National Council of Teachers of Mathematics, Twentieth Yearbook, compiled by the Committee on the Metric System, J. T. Johnson, chairman. Bureau of Publications, Teachers College, Columbia University, New York, N. Y., 1948. 303 pages, illustrations, diagrams, tables, charts, maps, $9^1/_2$ by 6 inches, cloth, $3. Supplies a comprehensive view of metric usage at the present time as reported by 60 individuals and numerous organized groups active in widely varied fields. It surveys the history, nature, and advantages of the metric system and offers specific programs for its adoption both in general use and in the classroom throughout the United States and the British Empire.

NFPA HANDBOOK OF FIRE PROTECTION. By Crosby-Fiske-Forster. Tenth edition. National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., 1948. 1,544 pages, illustrations, diagrams, charts, tables, $7^3/_4$ by 5 inches, fabrikoid, $9.50. Aims to present in compact form, for ready reference, all the essential information on fire prevention that time has stabilized into good practice. Among the new features are a chapter on chemistry and physics of fire, a chapter on water spray protection, and a complete new treatment of the general field of building construction. The new chapter on magnesium and other combustible metals outlines fire hazards and methods of protection. A table of trade names of plastics gives the properties of each.

NOMOGRAMMER OVER KOMPLEKSE HYPERBOLSKE FUNKTIONER (NOMOGRAMS OF COMPLEX HYPERBOLIC FUNCTIONS). By J. Rybner. Jul. Gjellerups Forlag, Copenhagen, Denmark, 1947. 35 pages plus many charts and diagrams with no pagination, 12 by $8^1/_2$ inches, stiff, cardboard, spiral binding, Danish Kr. 24.00. Written both in Danish and English, this book contains nomograms of various complex hyperbolic functions of particular interest in electrical engineering. There are also alignment charts of a number of elementary functions often used in electrotechnics. A list of formulas for circular and hyperbolic functions and some formulas for 4-terminal networks and transmission lines also are included. The notation adopted differs in several respects from English usage, but the formulas printed on each nomogram and the explanations given in the introduction will help avoid confusion.

# PAMPHLETS • • • •

**The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.**

**Catalogue of Motion Pictures and Slide Films for Employee Training in Petroleum and Allied Fields.** An analysis and listing of over 1,300 available films, with source index and geographical list of film libraries. Cost per copy, $3 from the American Petroleum Institute, 50 West 50th Street, New York 2 N. Y.

**Bi-Monthly Supplement, October 194[illegible] Underwriters' Laboratories, Inc., List of Inspected Appliances, Equipment, and Materials.** Available upon request from Underwriters' Laboratories, Inc., 161 Sixth Avenue, New York 13, N. Y.

**1948-49 RMA Trade Directory and Membership List.** Listing all officers, directors, members, and trade names of member companies. Available from the Radio Manufacturers Association Headquarters, 1317 [illegible] Street, Washington 4, D. C.

**Table and Mollier Chart for Ammonia Below −60 Degrees Fahrenheit.** National Bureau of Standards Circular 472, priced at 10 cents from the Superintendent of Documents, United States Printing Office, Washington 25, D. C.

**World Electrical Current Characteristics.** A handy reference for the use of American electric equipment manufacturers and others needing reliable information on the electrical supply of foreign countries. Available at 15 cents a copy from the Superintendent of Documents, United States Printing Office, Washington 25, D. C.

**Spectral-Transmissive Properties and Use of Eye-Protective Glasses.** National Bureau of Standards Circular 471, containing data on the most widely distributed brands and types of protective glasses from harmful ultraviolet, visible, or infrared radiant energy. 20 cents a copy from the Superintendent of Documents, United States Printing Office, Washington 25, D. C.

**The Payoff in Research.** A booklet containing 12 stories of various institutions benefitting from research. Priced at 50 cents a copy from the Engineering College Research Council, Iowa State University, Iowa City, Iowa.

**1945-48 Supplement, Bibliography of Industrial Radiology.** Part two of this publication which supplements part one 1942–48. Cost is $2 from the St. John X-Ray Laboratory, Califon, N. J.

**Basic Radio Propagation Predictions (Three Months in Advance).** Number 50 for January 1949 and number 51 for February 1949, each available for 10 cents from the Superintendent of Documents, United States Printing Office, Washington 25, D. C.

**Air Conditioning Design.** A booklet on the general procedure for designing an air conditioning system. Copies obtainable from the American Society of Refrigerating Engineers Headquarters, 40 West 40th Street, New York 18, N. Y., at 40 cents each.